THE TEACHING OF MATHEMATICS IN AUSTRALIA

REPORT PRESENTED TO THE INTERNATIONAL COMMISSION ON THE TEACHING OF MATHEMATICS

BY

H. S. CARSLAW

Professor of Mathematics in The University of Sydney

Representative of Australia on the Commission

SYDNEY

ANGUS & ROBERTSON LTD.

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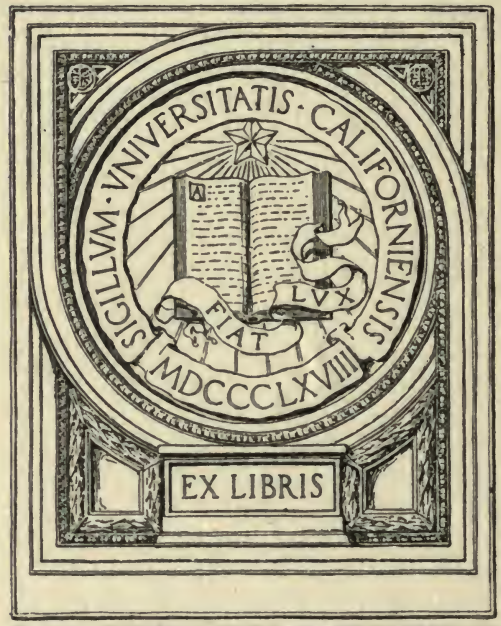
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INTRODUCTION

This Report deals with the teaching of Mathematics in Australia in the Secondary Schools, the Technical Colleges and Schools of Mines, the Government Colleges for the Training of Teachers, the Royal Military and Naval Colleges, and the Universities.

The conditions vary in the different States, and also not a little in the same State. What can be done in New South Wales and Victoria, each with a population of about one million and a half, and in their large capital cities, Sydney and Melbourne, cannot be looked for in Western Australia, whose people do not yet number 300,000, nor in Tasmania, which has not yet reached 200,000. So far as the States have seen fit to legislate in such matters, the Departments of Public Instruction administer their educational affairs. The chief work of these Departments until recent years has been the creation, development and organisation of an efficient system of Primary Education. It is recognised that this duty has been well performed. With the scattered population of our country districts, the task has been, and is, no light one. However it is now a definite part of the educational policy of the States to enlarge the work of the Education Departments, so that they will more effectively co-ordinate and extend their educational activities. With this development—especially in New South Wales, Victoria and Queensland—Secondary Education is no longer being left to the Private Schools. In these States, and more recently in South Australia, to a greater or less extent, a system of State High Schools has been created, which will have a far-reaching influence on the future of Higher Education in Australia.

Such Technical Colleges and Schools of Mines as are to be found in Australia rarely attempt advanced courses of study. They are in some cases independent institutions; in others, they are provided and administered by the Departments of Public Instruction. In the near future the whole work of Technical Instruction

will probably be taken over by the States, and these institutions linked on the one hand with the High Schools, and on the other with the Universities.

The teachers in the Primary Schools, in the great majority of cases, now receive their training in Teachers' Colleges under the Departments of Public Instruction. The most important of these are intimately associated with the Universities. Most of the teachers in the Secondary Schools are University graduates, and an increasing proportion of the principal teachers in the Primary Schools also hold a University degree.

The Universities, though not State Universities in the usual sense of the term, are in most cases largely supported by the State. In some instances the proportion of their revenues derived from the Treasury is so large that, except for the freedom of their administration, it would be difficult to distinguish them from State institutions. Their government rests with the Senate of each University. On these governing bodies there is now to be found a fair number of official representatives. Whatever be the stage which any of these six institutions may have reached in their growth towards full University status, they can all be regarded as the crown of the educational system of which they form a part.

Finally, the educational work of the Federal Government, as distinguished from the State Governments, is confined to the training of the officers of the Military and Naval Forces of the Commonwealth. Full reference to the curricula of the Royal Australian Military College and the Royal Australian Naval College will be found below in its proper place.

In the preparation of this Report I have had the advantage of the co-operation of the Educational Section of the Australian Association for the Advancement of Science. At the Melbourne meeting in January, 1913, that Section appointed the following Committee to act with me in this matter:—The Directors of Education of Western Australia and Tasmania; R. H. Roe, Esq., Inspector-General of Schools, Queensland; Professor Chapman, of Adelaide; M. P. Hansen, Esq., Inspector of Secondary Schools, Melbourne; M. S. Sharman, Esq., and L. J. Wrigley, Esq., of the Teachers' College, Melbourne. From all of these gentlemen I have received valuable assistance.

I desire also to acknowledge the help I have received from the Education Departments in the different States, the officials of the Universities, the R.A. Military College, and the R.A. Naval College.

H. S. CARSLAW.

The University, Sydney,
February, 1914.

CHAPTER I.

THE INFLUENCE OF THE UNIVERSITIES ON THE WORK OF THE SECONDARY SCHOOLS.

§1. Since the Education Departments, at any rate until the last few years, neither provided Secondary Schools in any number nor exercised control over those which had been founded privately, it is natural that the chief influence upon the work of these schools has proceeded from the Universities. This influence has been exerted, not only through their requirements at matriculation, but also by a system of Public Examinations taken by pupils of the schools, whether they proposed to enter the Universities or not. Between these examinations and the Oxford and Cambridge Local Examinations there are many points of resemblance. The actual working of the system has differed from State to State, but throughout Australia the schools have looked to the syllabuses in the subjects of study for these examinations as their guide. The success or failure of their pupils in the examinations from year to year has been regarded as the chief test of the value of the school. They have so dominated Secondary Education in Australia that, even at the present time, the most satisfactory way of describing the extent of the school work in Mathematics, or in any other subject, would be to give copious extracts from the handbooks for these examinations, where the details of the subjects of study are to be found.

Such a system, however carefully managed, is not educationally sound. The schools are influenced too much by the external examination as a test of their work. The teachers are inclined to select such matter, and adopt such methods, as will lead to success in the examination, without considering whether they are equally satisfactory in educating the pupil; and, as separate papers are set in the different mathematical subjects of the school course, it has sometimes happened that pupils have taken up one or other of these subjects by itself instead of getting a suitable general training in all. Nor is the supervision of the work of the schools on this scale a proper function of any University.

It is satisfactory that in one of the States the Department of Public Instruction has now undertaken wide responsibilities in Secondary Education, and that in it an admirable system of Inter-

mediate and Leaving Certificates has been introduced—a system in some respects resembling that for the Leaving Certificate of the Scotch Education Department. In New South Wales the days of the University Public Examinations are very nearly ended.

In most of the other States modifications of the purely examinational system are at present under consideration. And though in the following pages considerable space must be given to the mathematical work of the Public Examinations, it is probable that the next few years will see many changes introduced, either in the direction of a much fuller official provision and supervision of Secondary Education, or in closer co-operation between Schools' Boards of the Universities and the Education Departments in Examination and Inspection.

In this chapter we shall describe the mathematical work of these examinations. In the next we shall refer more particularly to the work of the State High Schools as at present organised, and to the Intermediate and Leaving Certificate System of the Department of Public Instruction of New South Wales, to which reference has been made above.

The Public Examinations of the University of Sydney.

§2. Though these Examinations will very probably in a year or more have been superseded by the Intermediate and Leaving Certificates of the Department of Public Instruction, it is necessary to describe them here. The scheme, as it exists at present, includes a Junior and a Senior Examination. For a few years a Junior and Senior Commercial Examination were inserted, but these have now been discontinued. The Junior is held in June of each year; candidates are generally about 15 years of age, and the programme of the examination is meant to cover the first two or three years' work of a Secondary School. In recent years about 1100 candidates have entered annually for the examination. Every matriculated student of the University of Sydney, before entrance, has to pass in the mathematical papers of the Junior (Arithmetic, Algebra, and Geometry) or some equivalent examination; but almost all of those taking mathematical classes in their University course now pass the Senior Examination in mathematics, or some equi-

valent examination, before entrance. The Senior Examination is usually taken from one and a half to two and a half years after the Junior. It is held in November each year. The number of candidates has been very much smaller—only about 150.

In the Senior Examination either additional papers or separate questions have been set for Honours candidates, and separate Pass and Honours Lists have been issued. All students entering the Department of Engineering in the University of Sydney have to pass in Algebra, Geometry, Trigonometry, and Mechanics at this or some equivalent examination before matriculation.

§3. *The Junior Examination.* The following mathematical papers are set:—

Arithmetic. A full course of Arithmetic; but with respect to the English Tables of Weights and Measures, only those parts which are in general use are required.

Algebra. Up to quadratic equations with two unknown quantities, ratio, proportion, surds, and simple questions in fractional and negative indices.

Questions may be set involving the use of squared paper in simple equations and simple simultaneous equations.

Geometry. The paper in Geometry contains questions in Practical and Theoretical Geometry. The subject matter covers roughly the theorems and problems in Euclid, Books I., II., and III. In addition, questions in Easy Numerical Trigonometry of the Right-Angled Triangle are included in this paper. Any proof of a proposition which appears to the examiners to form part of a systematic treatment of the subject is accepted. The order in which the theorems and problems are stated in the schedules is not imposed as the sequence of their treatment. Hypothetical constructions are permitted. The schedules correspond to those of the Cambridge Previous Examination, with the omission of the propositions depending on the theory of ratio and proportion. These are placed in the schedule for the Senior Examination. But a theorem as to a set of parallel lines cutting two intersecting lines is included, so that there may be a proper reasoned foundation for the work in Numerical Trigonometry.

The recommendations of the different Committees of the English Mathematical Association are followed generally in the mathematical work of these examinations.

The following Table shows the numbers entering and passing in the different papers of the Junior Examination of June, 1912:—

THE JUNIOR PUBLIC EXAMINATION HELD IN JUNE, 1912.

Subjects of Examination.	No. who entered.	No. who passed. Class I.	Class II.	Class III.	Total.
History of England	696	56	212	243	511
Geography	578	52	170	214	436
English	1119	166	317	378	861
French	658	25	87	267	379
German	46	9	11	14	34
Italian	1	—	—	1	1
Latin	473	37	85	185	307
Greek	25	6	4	9	19
Arithmetic	1154	159	310	445	914
Algebra	1035	149	253	388	790
Geometry	1009	86	237	404	727
Inorganic Chemistry	229	19	29	114	162
Physics	55	8	17	20	45
Geology	82	10	35	29	74
Botany	46	5	11	23	39
Physiology	58	10	20	24	54
Drawing	133	14	26	58	98
Music	140	16	42	34	92

§4. *The Senior Examination.* The following mathematical papers are set:—

Algebra. Compulsory: Up to the three progressions, the Binomial Theorem for a positive integral index, and the properties and use of Logarithms. The graphical representation of simple algebraic functions. Questions in Arithmetic may also be inserted.—Optional: Convergence of Infinite Series. The Binomial, Exponential and Logarithmic Series.

Geometry. There are now two papers in Geometry. The first is for candidates who desire a Pass only. It contains questions in the subject matter, roughly, of Euclid, Books IV. and VI., treated in such a way as to apply to commensurable magnitudes. In the second paper, for Honours candidates only, questions are set on Modern Geometry, Solid Geometry, and the Parabola and Ellipse.

Plane Trigonometry. Compulsory: Up to solution of triangles and properties of triangles.—Optional: De Moivre's theorem, limits and simple series.

Elementary Analytical Geometry of the Straight Line and Circle, and the Elements of the Differential Calculus.

Mechanics. The Elements of Statics and Dynamics, including the following:—Velocity and acceleration in rectilinear motion, and in motion in a circle; the rectilinear motion of a uniformly accelerated particle; the laws of motion; resolution and composition of forces acting at a point; the equilibrium of forces acting on a rigid body in one plane; the centre of gravity; the simple machines, viz., the lever, the common balance, the inclined plane and the pulley; friction; work and energy.

The following Table shows the numbers entering and passing in the different papers of the Senior Examination of November, 1912:—

THE SENIOR PUBLIC EXAMINATION HELD IN NOVEMBER, 1912.

Subjects of Examination.	No. who entered.	No. who passed. Class I.	Class II.	Class III.	Total.
History of Europe	60	7	23	21	51
Ancient History	69	10	20	27	57
Geography	28	9	11	7	27
English	186	37	57	56	150
French	155	8	27	68	103
German	10	2	3	3	8
Latin	150	10	37	71	118
Greek	16	4	4	7	15
Algebra	172	29	59	57	145
Geometry	174	28	60	60	148
Trigonometry	168	19	58	71	148
Analytical Geometry	19	8	5	2	15
Elementary Surveying and Astronomy	7	2	—	2	4
Mechanics	74	7	21	30	58
Applied Mechanics	8	1	3	1	5
Inorganic Chemistry	26	4	4	12	20
Physics, Part I.	32	4	6	16	26
Geology	16	3	5	7	15
Physiology	14	4	3	7	14
Botany	9	3	2	4	9
Zoology	5	1	—	2	3
Plane Geom. Drawing and Perspective	29	1	4	13	18
Freehand and Model Drawing	32	8	9	10	27
Drawing in Colour	7	4	1	1	6
Music	14	3	9	1	13

THE PUBLIC EXAMINATIONS OF THE UNIVERSITY OF MELBOURNE.

§5. The scheme of Public Examinations includes the Junior and Junior Commercial, and the Senior and Senior Commercial Examinations. For many years there was also a Primary Examination, intended to cover the work usually taught in the Primary Schools. This was discontinued in 1913. The usual age for the Junior is about 16, and for the Senior about 18. The examinations are held twice a year—in December and in February; but the February examination is purely a supplementary examination for candidates who fail to reach the required standard in December in not more than two of their subjects.

At entrance to the University a certain amount of mathematics is required for all the Faculties, except Laws and Music. The details of these requirements in mathematics are as follows:—

Agriculture—Arithmetic.
Arts—Algebra or Geometry.
Dentistry—Arithmetic.
Engineering—Algebra, Geometry, Trigonometry, and Elementary Mechanics (Senior); Arithmetic.
Medicine and Veterinary Science—Arithmetic, Algebra, Geometry.
Science—Arithmetic, Algebra, Geometry, Trigonometry.
The subjects may be taken at either the Junior or Senior Standards unless otherwise stated.

In the Senior Examination in December, Pass and Honours papers are set, and separate Pass and Honours Lists are issued. In recent years there have usually been about 300 candidates for the Primary; about 2000 for the Junior, of whom about 50 would be Junior Commercial candidates; and about 400 for the Senior. The number entering for the Senior Commercial has been almost negligible. At the present time the whole question of the relation of the Public Examinations to the work of the schools of Victoria is being reviewed.

§6. *The Junior Examination.* The following mathematical papers are set*:—

Arithmetic. More advanced treatment of work formerly prescribed for the Primary Examination, together with—Graphic arithmetic; stocks and shares; rates and taxes; insurances; profit and loss; percentages; partnerships; compound interest; discount; exchanges; mensuration of plane rectilineal figures and the circle; mensuration of solid figures, viz., sphere, cone, prism, pyramid, and cylinder.

Algebra. More advanced treatment of work formerly prescribed for the Primary Examination, together with—H.C.F., L.C.M., quadratic equations, simultaneous equations of two unknowns, both simple, or one quadratic and one simple. Easy examples in surds and indices. The three progressions. Problems. Graphic solution of the above-mentioned equations.

Geometry. The scope of this paper is practically the same as that of the corresponding paper in the Sydney Junior. However questions in Numerical Trigonometry are not included. A separate paper is given in Trigonometry in this examination, but it is taken by only a small number of the candidates.

Trigonometry. A simple treatment of the following:—Angular measurements; addition formulæ; relations between the sides and angles of a triangle; the use of logarithmic tables; solution of triangles. Simple examples in heights and distances.

* The papers in mathematics in the Public Examinations are set in general accordance with the recommendations contained in "The Teaching of Elementary Mathematics: A Report of the Committee appointed by the Mathematical Association."

The following Table shows the numbers entering and passing in the different papers of the Junior Public and Junior Commercial Examinations of December, 1912. In this Table are included 39 candidates who entered for the Junior Commercial Examination. The details of the mathematical subjects for the two examinations are the same:—

JUNIOR PUBLIC AND COMMERCIAL EXAMINATIONS, DECEMBER, 1912.

Subjects.	Presented.	Passed.*	Failed.	Obtained Distinction.
Bookkeeping	90	52	38	8
English	1,629	1,228	401	276
Arithmetic	1,553	1,117	436	295
Algebra	1,435	1,053	382	314
Geometry	1,047	872	175	273
Trigonometry	144	84	60	12
Geography	1,242	807	435	142
History	1,260	878	382	155
Physics	385	221	164	48
Chemistry	200	139	61	19
Anatomy and Physiology	149	121	28	32
Botany	75	48	27	1
French	1,150	804	346	181
German	186	116	70	13
Latin	793	444	349	142
Greek	80	58	22	*30
Drawing	301	177	124	38
Shorthand	61	43	18	11
Typewriting	31	26	5	2

* Including those obtaining "distinction."

§7. *The Senior Examination.* The following mathematical papers are set:—

Algebra. More advanced treatment of work prescribed for the Junior Public Examination, together with the remainder theorem; quadratic equations of two unknown quantities; ratio; proportion; variation; permutations and combinations; binomial theorem for positive integral exponent; logarithms.—*Honours:* More advanced treatment of work prescribed for the Pass Examination, together with the elements of the theory of partial fractions; the elements of the theory of equations and determinants; exponential and logarithmic series.

Geometry. The Pass paper contains questions on the subject matter of Euclid, Books IV., VI. and XI., as now usually taught, and on the properties of the Parabola.—*Honours:* More advanced treatment of work prescribed for the Pass Examination, together with harmonic ranges, inversion, and the elementary geometry of the parallelopiped, pyramid, cone, cylinder and sphere. Elementary analytical geometry so far as relates to the point, line, circle, parabola and ellipse, referred to rectangular axes. Radical axis. Pole and polar; centres of similitudes.

Trigonometry. More advanced treatment of work prescribed for the Junior Public Examination, together with heights and distances and the general solution of simple trigonometrical equations. The simple treatment of circumscribed, inscribed and escribed circles.—*Honours :* More advanced treatment of work prescribed for the Pass Examination, together with De Moivre's theorem and its simpler applications; summation of simple finite trigonometrical series; fundamental formulæ connecting sines and cosines of the sides and angles of spherical triangles.

Elementary Mechanics. Rectilinear motion with uniform acceleration; composition and resolution of velocities and accelerations; Newton's laws of motion; composition and resolution of forces in one plane; projectiles; uniform motion in a circle; momentum and impact; principle of work; equilibrium of a particle and a rigid body under forces in one plane; inclined plane; lever; pulley; centroids.—*Honours :* Simple harmonic motion, together with more advanced treatment of the work prescribed for the Pass Examination.

The mathematical subjects at the Senior Commercial Examination are as follows:—

Commercial Arithmetic. The work prescribed for the Junior Public Examination in Arithmetic, together with the following :—Freights; rates of exchange and transactions with home and foreign Bills; the coinages, weights and measures of the principal commercial countries of the world. Debentures, preference stock, ordinary stock, profits and dividends; liabilities, insolvency and liquidation. Bankers' interest. The use of logarithms, more particularly for problems on compound interest, insurance and annuities. Methods of calculating rates and taxes. Compound interest with special reference to repayment of loans.

Algebra. As for the Senior Public Examination.

The following Table shows the numbers entering and passing in the different papers of the Senior Examination of December, 1912. There were no candidates on that occasion for the Senior Commercial Examination :—

SENIOR PUBLIC EXAMINATION, DECEMBER, 1912.

Subjects.	Presented.	Passed.*	Failed.	Obtained Honours.
English Language and Literature	378	274	104	55
British History	372	282	90	66
Greek	35	31	4	14
Latin	107	76	31	16
French	176	168	8	58
German	58	40	18	16
Algebra	199	115	84	6
Geometry	159	112	47	9
Trigonometry	175	116	59	9
Physics	166	124	42	23
Chemistry	134	108	26	25
Anatomy and Physiology	23	22	1	6

Subjects.	Presented.	Passed.*	Failed.	Obtained Honours.
Botany	17	13	4	5
Geography	155	102	53	14
Geology	105	54	51	12
Drawing	42	20	22	13
Elementary Mechanics	47	37	10	8
Shorthand	11	7	4	—
Typewriting	2	2	—	—

* Including those who obtained "honours."

In February, 1912, there were 476 candidates for the Junior and 12 for the Junior Commercial; 108 for the Senior, and none for the Senior Commercial.

THE PUBLIC EXAMINATIONS OF THE UNIVERSITY OF ADELAIDE.

§8. The scheme of Public Examinations includes a Primary, a Junior and Junior Commercial, a Senior and Senior Commercial, and a Higher Examination. The Primary Examination is held in August or September of each year, and the regulations are not unlike those formerly in force in Victoria. It is supposed to mark the completion of the work of the Primary School. The candidates for this examination will be about 12 years of age. That such an examination should continue is a little surprising. The Junior, Senior and Higher Examinations cover much the same ground as the Junior and Senior Examinations in New South Wales and Victoria, but the programmes in mathematics, at any rate, do not include the work prescribed there for Honours. The course is meant to cover about six years. These examinations are held in November or December each year; but a supplementary examination takes place each March, chiefly for those who desire to complete their matriculation examination at the University. The requirements in Mathematics at entrance to the different Faculties are as follows:—

Arts. The Senior Examination must be passed in Arithmetic and Algebra, and Geometry, or candidates must satisfy the Faculty of their fitness to enter upon the course of study chosen for the degree. All candidates must pass in these subjects before taking their degree.

Science. The Senior Examination must be passed in Arithmetic and Algebra, and Geometry.

Engineering. The Senior Examination must be passed in Arithmetic and Algebra, Geometry, and Trigonometry.

Medicine. The Senior Examination must be passed in Arithmetic and Algebra, and Geometry, before entrance upon the medical course.

Laws and Music. No compulsory Mathematics.

Up till 1913, some of the schools of Western Australia sent up their pupils for the Public Examinations of the University of Adelaide, so that the statistics for these examinations include candidates from that State as well as from South Australia. With the foundation of the University of Western Australia in Perth, this practice is now being discontinued. Next year the University of Western Australia will hold two School Examinations—the Junior, for those about 15 or 16, and the Leaving Certificate, for those about 17 or 18. The examinations are to be under the control of a Board consisting of three members of the University staff, two representatives of the Education Department, and two representatives of the Private Secondary Schools.

§9. *The Primary Examination.* The following mathematical papers are set:—

Arithmetic. Easy questions on the elementary processes of Arithmetic, including fractions, non-recurring decimals, practice, and rectangular areas and volumes.

Algebra. Elements of algebra, including addition, subtraction, multiplication, division, easy fractions, easy equations of the first degree containing not more than two unknown quantities, with problems leading to such equations.

*Geometry.** Practical Geometry: The following constructions and easy extensions of them: Bisection of angles and of straight lines; construction of perpendiculars to straight lines; simple cases of the construction of triangles from sufficient data; construction of parallels to a given straight line; construction of angles equal to a given angle.—

*The following additional remarks apply to all the Geometry papers in these examinations:—

Every candidate must be provided with a ruler graduated in inches and tenths of an inch and in centimetres and millimetres, a small set square, a protractor, compasses furnished with a hard pencil point, and a hard pencil.

Questions may be set in which the use of the set square or of the protractor is forbidden.

Figures should be drawn accurately with a hard pencil.

Any proof of a proposition will be accepted which appears to the examiners to form part of a logical order of treatment of the subject. In the proofs of theorems and deductions from them, the use of hypothetical constructions is permitted.

Theoretical Geometry: The substance of the theorems contained in Euclid, Book I., Propositions 4-6, 8, 13-16, 18, 19, 26-30, 32; questions upon these theorems, easy deductions, and arithmetical illustrations.

§10. *The Junior Examination.* The following mathematical papers are set:—

Arithmetic. As for the Primary Examination and, in addition: interest and discount, percentages, profit and loss, ratio and proportion, unitary method, square roots, stocks and shares, metric system and approximations, areas of parallelograms, triangles and circles, volumes of prisms and pyramids.

Algebra. As for the Primary Examination and, in addition: fractions and factors; greatest common measure and least common multiple; the solution of equations of the first degree and questions producing such equations; and the solution of easy quadratic equations involving one unknown quantity. Questions may be set on graphs, and when such questions are set, squared paper will be provided.

Geometry. As for the Primary Examination and, in addition:— Practical Geometry: Simple cases of the construction of quadrilaterals from a sufficient number of data; division of straight lines into a given number of equal parts; construction of a triangle equal in area to a given polygon; construction of tangents to a circle; construction of common tangents to two circles.—Theoretical Geometry: The substance of the theorems contained in Euclid, Book I., Propositions 33-41, 43, 47, 48, and Book III., Propositions 3, 14-16, 18-22, 31; questions upon these theorems, easy deductions, and arithmetical illustrations.

§11. *The Senior Examination.* The following mathematical papers are set:—

Arithmetic and Algebra.

Arithmetic. The theory of the various processes; the elements of mensuration, including the areas of parallelograms, triangles, circles, and the surfaces of spheres and cones; the volumes of parallelopipeds, prisms, pyramids, spheres and cones.

Algebra. As for the Junior Examination and, in addition: quadratic equations involving one or more unknown quantities, and problems leading thereto; indices and surds; ratio and proportion; the nature of logarithms, and the use of logarithms to the base 10.

Geometry. As for the Junior Examination, with the following additions:—Euclid, Book VI., 1-8, 19, 20, 23, together with propositions A and D.

Trigonometry. The usual course up to the solution of triangles with logarithms.

The Higher Examination. The following mathematical papers are set:—

Algebra and Trigonometry.

Algebra. As for the Senior, with problems of greater difficulty; the theory of quadratic equations; indeterminate equations; arithmetical, geometrical, and harmonical progressions; scales of notation; permutations and combinations; the binomial theorem, including fractional and negative indices.

Trigonometry. As for the Senior, with problems of greater difficulty; angles of unlimited magnitude; submultiple angles; inverse notation.

Geometry and Trigonometry.

Geometry. The substance of Euclid, Books I. to IV., VI., and XI., with exercises.

Trigonometry. As for Algebra and Trigonometry; the solution of triangles, including the ambiguous case; heights and distances; the inscribed, circumscribed, and escribed circles of a triangle; the area of the circle.

Applied Mathematics. Elementary statics, dynamics, and hydrostatics.

§12. *The Commercial Examinations.* The following mathematical papers are set in the Junior Commercial Examination:—

Commercial Arithmetic. Theory and practice of the processes of general arithmetic; short methods in multiplication and division; short methods in mental arithmetic, including multiplication, division, prices of articles, practice, interest and discount; addition of long totals and cross totals, simple and compound; fractions and decimals; approximations, including the decimalization of money, decimalized practice, contracted multiplication and division of decimals; the calculation of simple areas and volumes; profit and loss; percentages and averages; proportion, practice, square root; interest and discount, commission and brokerage, stocks and shares; the coinages and most important weights and measures of the principal countries of Europe and America, and of India, Japan and China.

Algebra and Geometry. As for the Junior Examination.

The following mathematical papers are set in the Senior Commercial Examination:—

Commercial Arithmetic. As for the Junior Commercial Examination, and in addition: the use of common logarithms and logarithmic tables; equation of payments; the application of logarithms to problems of compound interest and annuities; duodecimals; foreign exchange and foreign bills of exchange; statistics; the areas of rectilineal figures, circles, spheres and cones; the volumes of prisms, cones, pyramids and spheres.

Arithmetic and Algebra; Geometry; and *Trigonometry* As for the Senior Examination.

§13. The following tables give the statistics for these examinations in 1912:—

PRIMARY EXAMINATION.

Subjects.	Entered.	Failed.	Passed.
English	1,474	275	1,182
Arithmetic	1,474	284	1,173
Geography	1,123	488	617
English History	1,370	340	1,013
Greek	23	4	19
Latin	602	237	357
French	332	126	196
German	82	28	53
Algebra	1,297	458	822
Geometry	925	288	628
Drawing	101	57	41
Theory of Music	1	0	1

JUNIOR EXAMINATION.

Subjects.	Entered.	Failed.	Passed.
English Literature	798	238	544
English History	712	215	478
Geography	467	193	244
Greek	48	22	21
Latin	440	164	245
French	331	151	159
German	125	46	77
Arithmetic	811	255	539
Algebra	790	259	513
Geometry	634	262	359
Physics	323	97	197
Chemistry	190	72	104
Physiology	131	90	39
Botany	120	50	67
Drawing	74	30	43
Theory of Music	1	1	0

SENIOR EXAMINATION

Subjects.	Entered.	Failed.	Passed.
English Literature	334	114	214
Modern History	288	92	176
Ancient History	16	4	11
Greek	58	21	28
Latin	295	139	138
French	155	56	90
German	78	29	46
Arithmetic and Algebra	372	219	144
Geometry	315	86	221
Trigonometry	242	79	155
Physics	196	81	102
Chemistry	114	57	45
Physiology	59	18	38
Botany	31	12	18
Physical Geography and Geology	45	15	25
Drawing	40	17	23
Theory of Music	0	0	0

Higher Examination.

Subjects.	Entered.	Failed.	Passed.
English Literature	58	18	38
Modern History	40	9	31
Ancient History	10	1	9
Greek	25	7	18
Latin	70	32	37
French	47	14	31
German	36	4	31
Algebra and Trigonometry	94	37	52
Geometry and Trigonometry	83	33	47
Applied Mathematics	18	5	12
Physics	75	24	42
Chemistry	68	25	38
Biology	35	12	18
Physiology	0	0	0
Botany	3	1	2
Physical Geography and Geology	2	0	2
English Essay	45	—	—

Junior Commercial Examination.

Subjects.	Entered.	Failed.	Passed.
English Literature	75	17	55
Commercial Arithmetic	76	24	50
Commercial Geography	77	32	43
Book-keeping	78	17	59
Business Correspondence	48	20	27
Shorthand	48	31	10
English History	38	13	21
French	4	3	1
German	12	4	7
Algebra	30	11	13
Geometry	2	1	1
Physics	11	3	7
Chemistry	1	1	0
Typewriting	69	8	59

Senior Commercial Examination.

Subjects.	Entered.	Failed.	Passed.
Commercial Arithmetic	6	3	3
Book-keeping	9	2	7
Commercial Geography	5	2	3
Commercial History	5	2	3
English Literature	5	2	3
French	2	1	1
Arithmetic and Algebra	5	2	3
Geometry	1	0	1
Physical Geography and Geology	3	1	2
Shorthand	2	0	2

The Public Examinations of the University of Queensland.

§14. Until the year 1910 the Secondary Schools of Queensland usually sent up their pupils for the Public Examinations of the

University of Sydney, held at centres in the Northern State, and the requirements of these examinations were the controlling factor in their work. The Public Examination system has now been adopted by the new University of Queensland. The mathematical programmes for its Junior and Senior Examinations are practically the same as those in Sydney, so it is unnecessary to devote further space to them. The regulations for entrance to the three Faculties of Arts, Science and Engineering, which at present constitute the University, include the following mathematical subjects:—

Arts—Arithmetic, Algebra, and Geometry—at the Junior Standard.

Science—Same as Arts.

Engineering—Algebra, Geometry, Trigonometry, and Mechanics—at the Senior Standard.

The Statistics for the Examinations in 1912 are to be found in the following Tables:—

JUNIOR PUBLIC EXAMINATION, 1912.

Subjects.	No. who Sat.	No. who Obtained Distinction.	No. who Passed.	No. who Failed.
History of England	298	8	139	151
Geography	276	29	168	79
English	416	12	213	191
French	231	4	122	105
German	72	3	30	39
Latin	196	7	80	109
Greek	36	2	18	16
Arithmetic	424	23	239	162
Algebra	347	29	167	151
Geometry	346	42	181	123
Inorganic Chemistry	113	17	51	45
Physics	76	5	41	30
Geology	33	9	17	7
Botany	29	5	19	5
Physiology	67	12	31	24
Drawing	70	5	30	35
Music	36	8	20	8

SENIOR PUBLIC EXAMINATION, 1912.

Subjects.	No. who Sat.	No. who Obtained Distinction.	No. who Passed.	No. who Failed.
History of Europe	34	5	22	7
Ancient History	28	1	17	10
Geography	14	6	6	2
English	78	6	36	36
French	40	3	19	18
German	13	2	6	5
Latin	38	3	18	17
Greek	16	1	11	4
Algebra	68	6	38	24
Geometry	61	19	35	7
Trigonometry	63	13	37	13

Subjects.	No. who Sat.	No. who Obtained Distinction.	No. who Passed.	No. who Failed.
Conic Sections	1	—	1	—
Elementary Surveying and Astronomy	2	—	1	1
Mechanics	27	2	16	9
Applied Mechanics	3	—	2	1
Inorganic Chemistry	19	1	12	6
Physics—Part I.	3	—	1	2
,, Part II.	1	1	—	—
Geology	9	1	8	—
Physiology	3	2	1	—
Botany	8	3	5	—
Geom. Drawing and Perspective	15	—	6	9
Freehand and Model Drawing	6	2	1	3
Drawing in Colour	1	—	1	—
Music	4	—	1	3

The Public Examinations of the University of Tasmania.

§15. The scheme of Public Examinations includes a Junior and a Senior Examination somewhat like the corresponding examinations in Sydney. The Education Department does not consider the plan adopted by the private Secondary Schools of working towards these examinations, as they are at present constituted, educationally sound. It believes that the Secondary School curriculum should cover, say, four years, and that the examination should be determined by the curriculum of the schools. A beginning has been made with the foundation of State Secondary Schools, two of which were opened early in 1913. The Education Department proposes, with the assistance of Departmental officers, Secondary School teachers, and representatives of the University, to frame a four years' curriculum on similar lines to that adopted in New South Wales, and it hopes to get the University authorities to recognise it. The Junior and Senior Public Examinations would, in these circumstances, be somewhat equivalent to the written papers of the Intermediate and Leaving Certificate Examinations of that State.

The programmes for the Junior and Senior Examinations of the University of Tasmania are somewhat like those of Sydney. The details for these will not be given. The University of Tasmania requires the following mathematical subjects to be taken before entrance to the Faculties of Arts and Science:—

Arts—Senior Arithmetic.

Science—Senior Algebra and Geometry, but students who have not passed this examination may be admitted if they satisfy the Faculty of their competency in these subjects.

Mathematics is not required at entrance to the Faculty of Laws.

The following Table gives the Statistics for the Public Examinations of 1912:—

Senior Public Examination, 1912.

Subjects.	Examined.	Passed.	Failed.	Obtained Credit.
English Language and Lit.	139	115	24	15
Modern History	111	73	38	22
Ancient History	1	1	0	0
Geography	69	43	26	6
Elementary Politics	1	1	0	0
Latin	87	65	22	9
Greek	5	5	0	5
French	78	58	20	17
German	12	12	0	3
Arithmetic	136	113	23	14
Algebra	131	86	45	12
Geometry	97	60	37	10
Trigonometry	37	26	11	9
Statics	6	1	5	0
Physics	25	18	7	4
Chemistry	56	34	22	11
Geology	31	10	21	2
Agricultural Science	2	2	0	1
Physiology and Hygiene	15	13	2	4
Drawing	31	19	12	4
Music	1	0	1	0

Junior Public Examination, 1912.

Subjects.	Examined.	Passed.	Failed.	Obtained Credit.
English	418	307	111	50
History	415	238	177	24
Geography	406	311	95	34
Latin	83	49	34	22
Greek	9	7	2	6
French	170	119	51	38
German	4	4	—	2
Arithmetic	432	347	85	116
Algebra	363	293	70	29
Geometry	273	176	97	25
Physics	41	18	23	2
Chemistry	65	49	16	13
Physiography	251	155	96	12
Botany	10	8	2	1
Physiology	94	64	30	19
Drawing	177	32	145	7
Shorthand	6	2	4	0
Music	1	1	0	1

CHAPTER II.

THE STATE HIGH SCHOOLS AND THE LEAVING CERTIFICATE SYSTEM.

§16. In the preceding chapter full details of the mathematical work required in the Public Examinations have been given because of the place these examinations have had, and, except in New South Wales, are still likely to have, in determining the character of the education of pupils from 13 to 17 or 18 years of age. We pass now to the courses of study in the State High Schools, and to the regulations for the Intermediate and Leaving Certificates in New South Wales, so far as they affect the mathematical work of the Schools.

In dealing with the State High Schools it will only be necessary to refer in detail to the States of Victoria and New South Wales. It is true that much has been done by the State in Queensland for Secondary Education. The Grammar Schools, in part supported by public money, have in past years brought higher education in Queensland within the reach of many, who, in the other States, could not have hoped to carry their studies past the elementary stage, and the Government has in the last two years created a number of High Schools in the larger centres not touched by the Grammar Schools.

In these last years a few State High Schools have also been established in South Australia, Western Australia, and Tasmania. However the mathematical work in all these schools is sufficiently described in the pages devoted to the Public Examinations.

The State High Schools of Victoria.

§17. In Victoria up till 1905 no attempt had been made to bring the private schools under general administrative control or to provide State Secondary Schools. Indeed, the Education Act, which defined the educational activities of the Department of Public Instruction, did not permit it to do more than engage in the work of Primary Instruction. In 1906 an Act for the Registration of Teachers and Schools was passed. Under its provisions all the schools of Victoria have to be registered, and all persons teaching in the Secondary Schools must now possess the Diploma in Education of the University of Melbourne or some equivalent qualification. Further, an Act was passed in 1910 authorising the establishment of

State High Schools and Higher Elementary Schools. There are now 40 of these schools in existence, supplying a four years' course of instruction, growing out of the primary stage. Admission to them is by a qualifying examination in the subjects prescribed for Grade VI. of the Primary Schools. As a rule, pupils enter about the age of 12. However, in contrast to the Primary Schools throughout Australia, and also in contrast to the High Schools in New South Wales, the education in the schools above the primary stage is not free.*

But this development in Victoria has not yet, to any great extent, changed the situation regarding Secondary Education in that State. The High Schools and Higher Elementary Schools, in the majority of cases, only provide courses of study up to the stage of the Junior Examination at Melbourne—that is, up to the age of 16. At present eight of the High Schools and nearly 200 pupils are doing work of a standard higher than that of the Junior Examination, or preparing for the Senior Public Examination.

On the other hand, the aim of all the large private Secondary Schools of Victoria is to give their pupils a complete Secondary Education. Quite a large number of their pupils remain till about the age of 18, and cover the work of the Senior Examination, Pass or Honours. The greater part of the Secondary Education of Victoria is still carried on in these schools.

§18. The courses of study in these Victorian State High Schools are divided into two parts. Part I. is a common course extending over two years. It is intended to be preparatory to a further course in these schools, or in Technical Schools or other educational institutions. Part II. consists of four specialised courses, one of which will be taken by pupils who have satisfactorily completed the first two years' course and desire to pursue their studies further on these lines. These specialised courses are as follows:—

(*a*) The Preparatory Professional (Secondary) Course;

(*b*) The Domestic Arts Course;

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* Education in all State Schools in Victoria is free up to the age of 14 years. In all Elementary and Higher Elementary Schools education is free throughout the course. In the High Schools a fee of £6 per annum is charged to children over 14 years of age, but free places and scholarships are provided on a moderate scale.

(*c*) The Agricultural Course;

(*d*) The Commercial Course.

Course (*a*) will be taken by those who are looking forward to becoming teachers in the schools, or to entering the University, or to gaining employment in the public service. It will also be taken by those desiring simply a good general education. Course (*b*) is meant for girls who do not take Course (*a*). Course (*c*) is provided in the Agricultural High Schools, and Course (*d*) is for pupils intending to follow commercial pursuits.

§19. The Timetable suggested for the common course of the First and Second Years is as follows:—

SUGGESTED TIME ALLOTMENT FOR THE FIRST AND SECOND YEARS.

English		5	periods per week.
Second Language		5	,, ,,
Mathematics			
Arithmetic	3 2		
Algebra	3 3		
Geometry	2 3	8	,, ,,
History and Civics		3	,, ,,
Geography		3	,, ,,
Elementary Science		4	,, ,,
Drawing		3	,, ,,
Manual Work –			
Boys—			
Woodwork or Metalwork or Modelling / Agriculture (where practicable)		4	,, ,,
Girls—			
Needlework		3	,, ,,
Cookery		6	,, ,,
Hygiene		1	,, ,,
Class Singing		1	,, ,,
		37	periods of 40 min.

NOTES.—1. Boys will take agriculture in the school plots, or upon the school farm, in alternate weeks with the branch of manual work taught.

2. Girls will take needlework and cookery in alternate weeks.

It is unnecessary to enter fully into the details of the mathematical work of these two years.

In *Arithmetic* the usual course is followed, only easy examples being required. It is intended that the work in mensuration should be largely practical, and that it should be correlated with the work in Geometry. Practice is to be given in drawing to scale. The use of algebraical symbols is recommended. The principles of percentages and fractions

are to be applied to easy problems in Income Tax, Municipal Rates and Taxes, Mortgages and Debentures, etc. Also throughout the work in Arithmetic practical problems are to be considered.

In *Algebra* the first year's work leads up to and includes the solution of simple equations and simple simultaneous equations. Squared paper is to be used. In the programme for the second year considerable space is given to factors, and the work does not go beyond quadratic equations.

In *Geometry* the usual division into a set of problems of construction and a set of theorems is followed. Roughly speaking, only the more important propositions of Euclid, Book I., and some of the simplest of Book III., are taken in this course. Arithmetical illustrations are recommended. Any proof will be accepted which forms a part of a systematic treatment of the subject. The figures are to be drawn accurately.

§20. The Third and Fourth Years' work—the Preparatory Professional (Secondary) Course. The Timetable suggested for this course is as follows:—

Subject.	Periods per Week. 3rd Year.	4th Year.
English	5	5
Second Language	5	5
Mathematics	9	9
Science (two subjects)	7	8
History and Civics	3	2
Drawing	3	4
Manual Work	3	2
Physical Training and Hygiene	1	1
Singing	1	1
	37	37

Students taking a third language will devote to this study six periods per week taken from the time assigned to manual work and mathematics or science.

The details of the mathematical work of these two years are appended:—

Arithmetic. Third and Fourth Years. Revision and extension of the preceding work. Approximations and the use of contracted methods of working. Square root. Mensuration of plane rectilinear figures and the circle. Also of solids, viz., the cylinder, cube, sphere, cone, prism and pyramid. Easy graphs. Interpolation. Easy exercises in the use of equations. Insurance (life, fire and marine).

Algebra. Third Year. Literal equations of the first degree in one or two variables. Quadratic equations with literal coefficients. Simultaneous equations with two unknowns, either both simple, or one quadratic and one simple. Symmetrical expressions of the third degree.

The remainder theorem. Variation and change of sign of $ax + b$ and $ax^2 + bx + c$. Also the maxima and minima of the second expression.

Fourth Year. In addition to the preceding, easy examples in surds and simple expressions in fractional and negative indices. The three progressions.

Geometry. Third and Fourth Years. This course includes roughly such parts of Euclid Books I. to III. as are usually studied. It may be taken as equivalent to the work prescribed for the Melbourne Junior Public Examination.

Trigonometry. The programme describes an easy course up to and including the solution of triangles with Logarithms. The formulæ for the half angles are excluded. The work of this course includes the use of Logarithm Tables, both in Trigonometry and Arithmetic.

The Department proposes to conduct an Intermediate Examination for which the pupils of the High Schools would compete. Pupils satisfying the examiners would be awarded the Intermediate Certificate. The conditions for the issue of this certificate are that pupils shall have passed a satisfactory examination in at least six subjects of the course, including four compulsory subjects:—English; one foreign language; one branch of Mathematics (Arithmetic, Algebra or Geometry); and one Science, or History, or Geography. They must be certified to have spent the full time allotted to the course, and to have made satisfactory progress in each of the remaining subjects.

§21. The Domestic Arts Course. The Timetable suggested for this course is as follows:—

Subject.	3rd Year.	4th Year.
1. English	5	5
2. History and Civics	3	3
3. Household management and household accounts	4	4
4. Elementary experimental science	4	—
5. Physiology	—	4
6. Sanitation, hygiene, first aid and ambulance work	3	3
7. Cookery and laundry work	7	7
8. Drawing, design and art work	3	3
9. Needlework, dressmaking and millinery	6	6
10. Physical training (20 min. daily)		
11. Singing	2	2
Periods per week	37	37

It will be noticed that no mathematical work is included. Those who complete the full course of study satisfactorily will be eligible for the Intermediate Certificate.

§22. The Agricultural Course. The Timetable suggested for this course is as follows:—

Subject.	3rd Year.	4th Year.
1. English	5	5
2. Mathematics	6	6
3. History and Civics	3	3
4. Geography and Physiography	3	3
5. Drawing	3	3
6. Manual Work	4	4
7. Agricultural Science	6	6
8. Practical Agriculture	7	7
Periods per week	37	37

NOTE.—A second language may be taken as an optional subject.

It seems worth while to give the Syllabus for Arithmetic and Practical Mathematics, as it forms a distinctive feature of this course.

PRACTICAL MATHEMATICS FOR FARM STUDENTS.

Third Year.

1. Revision of work of the second year and essential processes.

2. Paying, saving and investing money. Simple interest. Compound interest. (Interest and amount only.) Banking. Real Estate. Loans. Promissory Notes. Bank (or Commercial) Discount. Drafts and Money Orders.

3. Problems and business transactions connected with farm operations: *e.g.*, yield per acre, gross and net returns, values, percentages, profits, charges, commission, interest on capital, percentage returns per cow or sheep or from farm produce, rates and taxes, insurance.

4. Elementary book-keeping as applied to farm receipts and expenditure.

5. Mensuration. The work should cover:—

(a) The mensuration of the triangle, parallelogram, trapezoid, circle, prism, cylinder, sphere, pyramid and cone.

(b) The application of the principles of mensuration to the measurement of the area of fields, to computing the contents of tanks, drains, embankments, dams, silos, haystacks, timber, bricks, etc., used on the farm.

(c) The use of the following measuring instruments:—vernier, chain, and surveyor's steel bands.

(*d*) Elementary field sketching—

(*i.*) Use of drawing instruments, conventional signs, lettering, coloring, construction of scales, rough representation of hill features by contours.

(*ii.*) The construction, adjustment and use of the chain, plane-table, level and sextant.

(*iii.*) Computation of areas from dimensions given on map. (Contour maps will not be required.)

6. Elementary graphs showing, for example, variations in rainfall, temperature, yields, net returns, prices.

Fourth Year.

Revision and extension of the previous year's work. Partnerships. Instruments used in money transactions—cheques, bills, promissory notes. Commercial discount and present worth. Investments. Insurance.

The continued application of arithmetical principles to farm and business transactions, and to market reports. Graphs. Bookkeeping applied to the operations of the farm.

Mensuration applied to farm work. Plotting statistics, etc.

Simpson's rule.

Elementary Surveying.

Revision and extension of the previous year's work in field-sketching.

The construction, adjustment, and use of the prismatic compass, clinometer, theodolite and optical square (where supplied).

Survey and subdivision of land, including plane-table sketching, prismatic-compass sketching, and rough contour maps of the locality.

Use of the clinometer in estimating heights.

Field notes of a simple survey.

Computation of areas from dimensions given in a field-book.

Copying, reducing and enlarging maps.

Trigonometry.

Definitions. Relations between sides and angles of a triangle.

Trigonometrical ratios.

Practical application of trigonometrical ratios.

Angles of elevation and depression. Contrivance for measuring such angles.

Height and distance problems—(*i.*) How to find the breadth of a river; (*ii.*) to find the height of a tower, etc.

Logarithms.

Laws of indices. Logarithms. Multiplication and division by logarithms. Involution and evolution by logarithms. The application of logarithms to problems in simple and compound interest, discount, present worth.

§23. The Commercial Course. The following time allotment for the different subjects of the course is suggested:—

Subject.	Periods per Week. 3rd Year.	4th Year.
English	6	6
Correspondence writing, précis writing	5	5
Arithmetic	4	5
Algebra	4	
Commercial History	3	2
Commercial Geography	3	—
Shorthand, or French, or German	5	6
Bookkeeping	5	6
Office routine and business methods	—	1
Typewriting	—	4
Singing	1	1
Hygiene	1	1
Total periods per week	37	37

The mathematical work is as follows:—

Third Year.

Arithmetic. Long tots. Graphic arithmetic, stocks and shares, rates and taxes, insurances, profit and loss, partnerships, discount, exchanges, wholesale price plus freight and insurance charges. Customs duties. Rates of exchange, with home and foreign bills. Debentures. Preference stock, ordinary stock. Profits and dividends. Liabilities, insolvency, and liquidations.

Algebra. The work is the same as that prescribed for the Third Year of the Secondary Course.

Fourth Year.

Arithmetic. A fuller treatment of the work prescribed for the preceding year. The conversion of English weights and measures into foreign equivalents and *vice versa* from tables supplied. Bankers' interest. The use of logarithms, more particularly for problems on compound interest, with special reference to the repayment of loans.

Algebra. A fuller treatment of the work for the preceding year, and its application to the problems prescribed in arithmetic. Indices, the three progressions, logarithms.

The State High Schools of New South Wales.

§24. From small beginnings in 1903, when four State High Schools were opened, the High Schools of the Department of Public Instruction now hold a very important place in the educational system of New South Wales. Admission is only open to those who hold the Qualifying Certificate—or something equivalent to it—shewing that they have satisfactorily completed the course of study

prescribed for the fifth class of the Primary School. The usual age of entrance is about 13, and the courses of study are arranged to cover four years. In special circumstances the work may be spread over five years, and it is not improbable that this practice may become general. No fees are charged, and a very liberal provision of bursaries and maintenance grants has been made for those whose circumstances are such that it would otherwise be difficult for them to attend these schools. In 1913 there were 15 of these schools at work. The total enrolment was over 3200. About 1500 of the pupils are in their first year; about 1150 in their second; about 400 in their third, and about 100 in their fourth. There were in addition about 1400 pupils in other State Schools doing one of the first-year High School courses, and about 700 doing one of the second.

The smaller numbers in the more advanced classes of the High Schools are explained by the fact that this forward movement in State Secondary Education is quite recent. It was only in 1911 that the fees in the High Schools were abolished. The number of these schools was then increased to eight. Also the system of bursaries and maintenance grants, which has made these four year courses possible for many of the pupils, has been in working order only for these last two years. Instead of about 150 pupils from all the Secondary Schools of New South Wales—public and private—reaching the standard of the Senior Examination each year, as has been the case until now, we shall have about 600 pupils annually completing one of these four-year courses in the High Schools alone. The work required in the different subjects studied is quite up to the standard of the Senior Examination, and at the completion of the course the pupils will be presented for the Leaving Certificate Examination, to be described later.

§25. The Courses of Study. Alternative Four-Year Courses of Study are available in the High Schools, corresponding to the different types of school and the needs of the different classes of pupils. These are as follows:—The General Course; the Commercial Course; the Industrial Course; and the Domestic Arts and Science Course. The Timetables suggested for these courses are appended:—

GENERAL COURSE.

	Years—I., II., III., IV. (Periods, 45 minutes.)				
English	5	5	5	5	
History	3	3	3	3	
Geography	2	2	—	—	
Mathematics	8	8	8	8	
Elementary Science	4	4	—	—	
Physics	—	—	3	3	Two of the subjects to be taken.
Chemistry	—	—	3	3	
Biology	—	—	3	3	
Geology	—	—	3	3	
Economics	—	—	3	3	
(1) Foreign Language	6	6	5	5	Latin, Greek, French or German.
(2) Do. do.	(6)	(6)	(5)	(5)	
Drawing and Manual Work	4	4	4	4	
Music	—	—	1	1	

Physical Training: Ten minutes daily after the second morning period.

NOTE.—1. In the fourth year Mathematics may be reduced to four periods, and the four periods thus released devoted to other subjects.

2. (*a*) When a second foreign language is taken in the first and second years, omit Drawing and Manual Work and Geography.

(*b*) When taken in the third and fourth years, omit Music, Drawing, and Manual Work.

A pupil may be permitted to take up the study of a third foreign language in the third and fourth years. In this event four periods of Mathematics and three periods of Science will be omitted. The range of study in Mathematics, as presented for the third year, would thus be spread over the third and fourth years.

COMMERCIAL COURSE.

	Years—I., II., III., IV. (Periods, 45 minutes.)				
English	5	5	5	4	
History	3	3	3	3	
Geography	2	2	1	1	
Mathematics	6	6	4	4	
			(6)	(6)	Where second language is not taken.
Elementary Science	4	4	—	—	
Science	—	—	3	3	
Do. (optional)	—	—	(3)	(3)	Where second language is not taken.
(1) Foreign language	6	6	5	5	
(2) Do. do.	(6)	(6)	5	5	Optional in 1st and 2nd years.
Economics	—	—	2	3	
Business Principles and Practice	2	2	4	4	
Drawing and Manual Training	4	4	—	—	

Physical Training: Ten minutes daily, after the second morning period.

NOTE.—Where a second language is taken in the first and second years, Geography (two periods), Drawing, and Manual Training (four periods) to be omitted. Where a second language is not taken in the third and fourth years, an additional Science subject shall be taken, and six periods devoted to Mathematics. Where Shorthand is taken, Drawing and Manual Training (four periods) to be omitted.

INDUSTRIAL COURSE.

	Years—I.,	II.,	III.,	IV.
	(Periods, 45 minutes.)			
English	5	5	5	5
History	3	3	3	3
Geography	2	2	—	—
Mathematics	8	8	8	8
Elementary Science	4	4	—	—
Physics	—	—	3	3
Chemistry	—	—	3	3
*Botany, Elementary Agriculture, Geology, Zoology	2	3	3	3
Field Work, Drawing and Manual Work	8	7	7	7

Physical Training: Ten minutes daily, after the second morning period.

*Sciences to be chosen from this group according to the special aim of the course—Technical, Mining or Agriculture. In Agricultural Schools the Sciences to be taken from this group are as follows:—

1st year, Botany; 2 periods.
2nd ,, ,, ,, Elementary Agriculture; 1 period.
3rd ,, ,, ,, Zoology, 1 period.
4th ,, ,, 1 period. ,, 2 periods.

In mining centres Geology is to be taken as a third Science in the third and fourth years. The times shown in the first and second years are to be added to those devoted to Drawing, Manual and Field Work, making a total of ten periods per week.

DOMESTIC ARTS AND SCIENCE COURSE FOR GIRLS.

	Years—I.,	II.,	III.,	IV.
	(Periods, 45 minutes.)			
English	5	5	5	5
History	3	3	3	3
Geography	2	2	—	—
Mathematics	6	6	4	4
Elementary Science	4	4	—	—
Foreign Language	6	6	5	5
Chemistry	—	—	3	3
Sanitary Science and Hygiene	—	—	1	1
Cookery and Laundry	—	—	4	5
Drawing and Design Needlework, Dressmaking and Millinery	6	6	6	5
Music	—	—	1	1

Physical Training: Ten minutes daily, after the second morning period.

The programmes for the different mathematical subjects are the same as those described in the articles which follow dealing with the Intermediate and Leaving Certificates.

THE INTERMEDIATE AND LEAVING CERTIFICATES OF THE DEPARTMENT OF PUBLIC INSTRUCTION IN NEW SOUTH WALES.

§26. The programmes in the different subjects studied in these High Schools have recently been revised in connection with the organisation of the Intermediate and Leaving Certificate System in New South Wales. Not only the High Schools, but most of the Secondary Schools in the State are now directing their studies along

lines approved by the Board of Examiners for the Intermediate and Leaving Certificates, and their pupils will become candidates for these Certificates. This Board is presided over by the Director of Education, and is composed of four officers of that Department and four Professors of the University.

The Intermediate Certificate is awarded to pupils of two years' standing in these schools, at the completion of the courses of study for the first two years, provided that they pass the written examination in not less than four subjects, and that the Inspector of Secondary Schools, after inspection of the school and consultation with the headmaster, certifies that they have satisfactorily followed the subjects of their course of study other than those in which their examination has been passed. The examiners have before them the record of the school work and the teachers' reports upon the pupil.

The last two years of the school course are tested in a similar way by inspection and by the Leaving Certificate Examination. At this stage greater opportunity for specialisation is given, and the work of these two years is divided into Pass and Honours. Higher papers are set in the principal subjects, and it will be chiefly on the work in these papers that the Honours Certificates will be granted. As in the case of the Intermediate Examination, the danger of cramming for the written examination is made as small as possible by the proviso that the candidates must do satisfactory work in the other subjects of the approved course of study which they have chosen, while the record of their school work is again in the hands of the examiners. Further, the examination can only be taken after the approved course of study has been followed for a period of four years.

Under this scheme the Secondary Schools throughout New South Wales will now be inspected regularly by an Inspector of Secondary Schools, and the first steps have been taken towards that co-ordination of Higher Education which is so much needed. The Leaving Certificate is accepted by the University of Sydney in place of a pass at the Matriculation Examination, when the holder of the certificate has passed in the subjects which are required at entrance to the Faculty in which he desires to study. In addition, under the provisions of the University Amendment Act (1912), about 200* Exhibitions are to be awarded each year on the results of the Leaving Certificate Examination, entitling the holders to exemption

* But in 1914 the number is fixed at 100; in 1915, at 150.

from fees during their University course. Also, under the Bursary Endowment Act of the same year, provision is made for these Exhibitions being supplemented by maintenance grants on a liberal scale, when such assistance would be necessary to enable the student to enter the University and pass through his course.

The large increase in the number of High Schools, the institution of the Leaving Certificate System, and the creation of these University Exhibitions and Bursaries, mark an immense advance in the cause of Higher Education in this State.

The Courses of Study in Mathematics for the Intermediate and Leaving Certificates.

§27. We proceed to describe in general terms the courses of study in the mathematical subjects.

First and Second Years' Work.

Arithmetic. This forms a part of the First and Second Years' work for all pupils. It includes Mensuration, the plane figures named in the syllabus being the rectangle, triangle, parallelogram, quadrilateral, and circle. The solids are the rectangular box, prism, pyramid, cylinder, cone and sphere. The Simple Numerical Trigonometry of the Right-angled Triangle is also introduced. This will not be taken in the Arithmetic Course till after a simple Geometrical treatment has made possible a satisfactory discussion of the points involved.

Algebra. The work in Algebra of these two years goes up to simple cases of Simultaneous Quadratics. The variation and change of sign of the expressions $ax + b$ and $ax^2 + bx + c$ are to be studied graphically and algebraically.

Geometry. This course covers the subject-matter of Euclid, Books I.-III., with the usual freedom from his methods and sequence, except for the points noted below. Preliminary practical work in Geometry will in most cases have been done before entrance upon the course of the Secondary School.

A noticeable departure is made from the practice recommended by the English Board of Education and followed by a large number of English schools. It is recognised that much of the confusion in the earlier work of the schools in Geometry arises from the various ways in which the fundamental theorems are treated. These fundamental theorems are few; those of the congruence of triangles, and those of parallels. The circular of the Board of Education on "The Teaching of Geometry and Graphical Algebra in Secondary Schools" (No. 711, March, 1909) suggested that the earlier practical or

experimental investigation of these theorems—and of the angle-sum of a triangle—be taken as sufficient, and that they be accepted as facts which are as obvious and real to the pupil as the difference between white and black, or between his right-hand and his left. The course in Geometry would consist of the theorems which can be deduced, and the problems which can be solved, with the aid of these truths and the other fundamental assumptions of Geometry.

This advice is not followed in the programme for Geometry under the Intermediate and Leaving Certificate scheme. Instead of assuming these theorems on this experimental foundation, it is recommended that Euclid's treatment be followed, except possibly in the case of Book I., Prop. 4., to be accepted as an axiom. The schools are asked to take the congruence theorems for triangles in Euclid's order; then to adopt his Parallel Axiom, or one of its equivalents; and his treatment of parallels, or something akin to it. The theorem regarding the sum of the angles of a triangle is to be taken after the parallel theorems.

The uniformity of treatment asked for in the syllabus concerns only these fundamental theorems.

This method has been adopted in the High Schools for some years. It is now extended to the Secondary Schools coming under the Intermediate and Leaving Certificate scheme. In all other respects the teachers and pupils have the freedom from the methods and sequence of Euclid which are now common. For the sake of those unacquainted with the methods of teaching Geometry in English schools, it should, perhaps, be added that this freedom from Euclid's methods, proofs, and sequence, has only been won in the last few years, and that with it came a degree of confusion which rendered necessary, in the view of the Board of Education, such advice as they gave in the circular quoted above.

The Boys' Schools cover all the work of these two years in Mathematics. Many girls will also do the full course, but many others will not devote the same time to this work. The written examination in Mathematics for the Intermediate Certificate is so arranged that pupils can be examined in the part chosen; the papers being two in number, one devoted to Arithmetic and Algebra, the other to Geometry and Easy Numerical Trigonometry, upon a proper reasoned foundation.

The Third and Fourth Years' Work.

§28. The Third and Fourth Years' work is divided into Pass and Honours sections. Practically all pupils will have to do some mathematical work in these two years, but only those who have shown special aptitude for this study will attempt the full course. Indeed, some will only take part of the Pass Course, but all who desire their Leaving Certificate to count as equivalent to the Matriculation Examination will have to satisfy the examiners in one of the two Pass Mathematical Papers, and thus have to reach a certain standard in Algebra, Geometry, and Trigonometry. There are three Higher Papers set in Mathematics; one devoted to Geometry and Trigonometry; another to Algebra, Co-ordinate Geometry and the Elements of the Differential Calculus; and the third to Mechanics.

It will be seen from the sketch given below that the Pass work is similar to that required in the Senior Examination in Algebra, Geometry, and Trigonometry. The Higher work resembles that for Honours in the same examination. In both Pass and Honours Mathematics it will be found that the regulations allow for greater co-ordination between the mathematical subjects, and, especially in the case of boys, encourage the study of elementary science. Also the work of the schools, and the arrangement of the papers in both the Intermediate and Leaving Certificate Examinations, are so regulated that the custom of studying either Arithmetic, or Algebra, or Geometry—one or other only—which was possible under the Public Examination system, will now be killed. All pupils from the schools proceeding to the Leaving Certificate Examination in Mathematics will have had to study for some considerable time Arithmetic, Algebra, Geometry and Trigonometry, not as specialists, but as part of their general education. And for the mathematical specialist fuller time is given, his needs being provided for in the Honours work.

The nature of the work in Mathematics tested at the Leaving Certificate Examination is as follows:—

Algebra. The Pass work in Algebra distributed over the Third and Fourth Years includes what may be described as "Up to the Binomial Theorem, with a positive integral index." Interest and Annuities are introduced after Logarithms, and graphical illustrations of maxima and minima, etc., are to be given. The Arithmetic Course is supposed to have been completed in the first two years.

The additional work for Honours includes:—Convergence of Series; the Binomial Theorem with a fractional or negative index; the Exponential and Logarithmic Series.

It also comprises a course in Co-ordinate Geometry of the Straight Line and Circle, and a short Introduction to the Differential Calculus. In connection with the latter it is mentioned that only differentiation of powers of x and simple algebraic expressions need be attempted; and that the work is to be applied to the equations of tangents in Co-ordinate Geometry, to velocity and acceleration, and to the determination of important areas, surfaces and volumes.

Geometry. The Pass work completes the usual elementary course in Geometry, without Solid Geometry. The additional work for Honours is as follows:—*Modern Geometry*—including Transversals; Nine Point Circle; Harmonic Ranges and Pencils; Pole and Polar; Similitude; and Inversion. *Solid Geometry*—including the substance of Euclid, Book XI., 1-21, together with theorems relating to the surfaces and volumes of the simpler solid bodies. *Geometrical Conics*—including the more important properties of the Parabola and Ellipse.

Trigonometry. The Pass work takes the pupils up to the Solution of Triangles. The Honours work, in addition, includes a fuller treatment of the preceding, with Circular Measure, De Moivre's Theorem and certain types of series.

Mechanics. This subject is not divided into Pass and Honours. It comes as one of the Higher Papers in Mathematics. It is intended to be preceded and accompanied by experimental work. Indeed in many schools the course will be under the direction of the Science Master. It includes the usual elementary work in Statics and Dynamics, with Elementary Hydrostatics and Atmospheric Pressure.

The first examination under the new scheme took place in November, 1913. The number of candidates for the Intermediate and Leaving Certificates was as follows:—Intermediate Certificate, 1570; Leaving Certificate, 168. In the Intermediate Certificate Examination, 1570 entered for Arithmetic and Algebra, 1557 for Geometry and Easy Numerical Trigonometry. In the Leaving Certificate Examination, 155 entered for the two Pass Papers, and from 70 to 100 for the three Higher Papers. The standard of the mathematical work in this examination was most satisfactory.

In later years, as mentioned in §24, the number of pupils in the higher forms of the State Secondary Schools will increase, and the entry for both these examinations on this occasion is not to be taken as representative.

CHAPTER III.

MATHEMATICS AT THE TECHNICAL COLLEGES.

§29. In the preface it has been mentioned that under this heading only the higher Technical Institutions will be included. To the work of the Trade Schools and the Technical Continuation Schools reference need not be made, except to remark that the subject of Mathematics is represented in their curricula chiefly by specialised courses in Arithmetic. The truth, however, is that Technical Instruction has not yet attained a proper footing in our educational system in Australia. No community can hope to develop technical education on the basis of an elementary education alone; and this has been the foundation upon which the work of most of our institutions which claim the title of Technical College has been built. The recent development of State Secondary Education, and the foundation of Continuation Schools, will soon make possible a reorganization of Technical Instruction, at any rate, in some of the States.

In this chapter it will be convenient to take the work in each State separately.

Technical Education in New South Wales.

§30. Since 1890 there has been a Technical Instruction Branch in the Department of Public Instruction. The most important institution under its control is the Technical College in Sydney, but other Colleges have been founded in the chief towns throughout the State. The work in all of them is, to a great extent, of an elementary character. Higher Technical Education is at present available only in the Engineering School and Mining School of the University. With these the work of the Technical Colleges and Schools of Mines will, it is hoped, soon be brought more effectively into touch, so that the best of their students may have an opportunity of carrying on their studies to a higher level.

The Sydney Technical College has a Diploma Course for Day Students chiefly in the Departments of Mechanical and Electrical Engineering. The mathematical syllabus for these students is given below. The second syllabus describes the mathematical work in the evening classes, and it is followed in most of the other Technical Colleges.

Mathematics in the Diploma Course, Sydney Technical College.

First Year.

Arithmetic. Decimals, metric system of weights and measures, ratio and proportion, percentages, profit and loss, simple and compound interest, discount, area of walls, papering, etc., applications of square and cube root, logarithms, and use of mathematical tables.

Mensuration. The right-angled triangle; circumference of a circle; area of rectangle, parallelogram, triangle, quadrilateral, rectilineal figures, circle, sector and segments of a circle, cylinder, cone, and sphere; Simpson's rule; volume of the parallelopiped, prism, cylinder, ring, cone, pyramid, and sphere; the use of the slide rule.

Geometry. Godfrey and Siddons' Geometry, Part I. and Books I. and II.; exercises on angles and parallels, triangles, constructions, inequalities, parallelograms, simple loci, areas.

Algebra. Simple equations; problems on simple equations; simultaneous equations; problems on simultaneous equations; involution; evolution; factors; H.C.F. and L.C.M.; fractions; harder equations; literal equations; harder problems; quadratic equations; problems on quadratic equations.

Graphs. Plotting a point; use of squared paper; plotting statistics, etc.; graph of function; solution of simple and of simultaneous equations by graphs.

Trigonometry Measurement of angles—sexagesimal method, centesimal method, and circular measure; problems on these methods; trigonometrical ratios; ratios of certain angles; simple heights and distances; ratios of the same angle; identities; solution of trigonometrical equations.

Second Year.

Geometry. Godfrey and Siddons' Geometry, Books III. and IV.; exercises on the circle, construction of common tangents, other constructions, loci, ratio and proportion, similar triangles, rectangle properties.

Algebra. Simultaneous quadratic equations; harder factors, indices; surds; equations involving surds; ratio; proportion; variation; arithmetical, geometrical and harmonical progressions.

Graphs. Graphic solution of quadratic equations; maxima and minima; infinite and zero values; trigonometrical functions; practical applications.

Trigonometry. Ratios of two angles; ratios of multiple angles; use of logarithms and tables; sides and angles of a triangle; solution of triangles.

Arithmetic and Mensuration. Contracted multiplication and division; proportional parts and partnership; stocks and shares; problems relating to work, pipes, etc.; mixtures; exchange; frustum of pyramid and cone; wedge; frustum of wedge and prismoid; zone and segment of a sphere; similar solids; duodecimals; logarithms applied to Arithmetic and Mensuration; the slide rule.

Third Year.

Algebra. The theory of quadratic equations; permutations and combinations; the binomial theorem; logarithms.

Trigonometry. Submultiple angles; inverse notation; heights and distances; triangles and circles; limit of the visible horizon.

Statics. Components and resultants; parallel forces; moments; couples; three forces acting on a body; general conditions of equilibrium; centre of gravity; elementary machines; friction; work.

Dynamics. Velocity; acceleration; motion under gravity; laws of motion; application to simple problems; impulse, work and energy; projectiles; collision of elastic bodies; simple harmonic motion.

Evening Classes.

First Year.

Arithmetic. Decimals, metric system of weights and measures, ratio and proportion, percentages, profit and loss, simple and compound interest, discount, area of walls, papering, etc., applications of square and cube root, logarithms, and use of mathematical tables.

Mensuration. The right-angled triangle; circumference of a circle; area of rectangle, parallelogram, triangle, and quadrilateral, rectilineal figures, circle, sector and segments of a circle, cylinder, cone and sphere; Simpson's rule; volume of the parallelopiped, prism, cylinder, ring, cone, pyramid and sphere.

Geometry. Godfrey and Siddons' Geometry, Part I. and Books I. and II.; exercises on angles and parallels, triangles, constructions, inequalities, parallelograms, simple loci, areas.

Algebra. Simple equations; problems on simple equations; simultaneous equations; problems on simultaneous equations; involution; evolution; factors; H.C.F. and L.C.M.; fractions; harder equations; literal equations; harder problems; quadratic equations; problems on quadratic equations.

Graphs. Plotting a point; use of squared paper; plotting statistics, etc.; graph of function; solution of simple and of simultaneous equations by graphs.

Trigonometry. Measurement of angles—sexagesimal method, centesimal method, and circular measure; problems on these methods; trigonometrical ratios; ratios of certain angles; simple heights and distances; ratios of the same angle; identities; solution of trigonometrical equations; applications of algebraic signs; angles of any magnitude.

Second Year.

Algebra. Quadratic equations; simultaneous equations of the second degree; indices; surds; ratio; proportion; variation; arithmetical, geometrical and harmonical progressions.

Graphs. Graphic solution of quadratic equations; maxima and minima; infinite and zero values; trigonometrical functions; practical applications.

Geometry. Godfrey and Siddons' Geometry, Books III. and IV.; exercises on the circle, construction of common tangents, other constructions, loci, ratio and proportion, similar triangles, rectangle properties.

Trigonometry. Ratios of two angles. Transformations of products and sums; ratios of multiple angles; logarithms and use of tables; relations between the sides and angles of a triangle; solution of triangles.

Arithmetic and Mensuration. Contracted multiplication and division; proportional parts and partnership; stocks and shares; problems relating to work, pipes, etc.; mixtures; exchange; frustum of cone and pyramid; wedge, frustum of wedge and prismoid; zone and segment of a sphere; similar solids; duodecimals; logarithms applied to Arithmetic and Mensuration.

Technical Education in Victoria.

§31. At present in Victoria there are several largely attended Technical Colleges and Schools of Mines; notably, the Working Men's College in Melbourne, founded in 1887, the School of Mines at Ballarat, and the School of Mines at Bendigo. These two Schools of Mines were established in 1870-2, and, in the days when Victoria had a monopoly of such work, their students passed quickly into positions of importance in this great industry of Australia. The conditions under which they work now are different, and they do not flourish so vigorously. Much instruction of an elementary character is given in them, as in the other Technical Colleges scattered throughout the State.

The mathematical work in these Colleges is usually directed towards the Certificates issued by the Education Department in Victoria. In the mathematical subjects there are five such certificates, viz., Preliminary Mathematics; Mathematics, Grades I, II and III; and Spherical Trigonometry. The programmes for each are appended:—

Preliminary Mathematics.

It is desirable that students taking this course shall have reached the standard of mathematical knowledge expected of a pupil who has spent at least one year in the Sixth Class of a State school.

Arithmetic. Decimals; approximations; square root; the metric system; mensuration of plane rectilinear figures, and of the circle; mensuration of rectangular solids, and of the sphere, prism, pyramid and cylinder.

Algebra. The elements of Algebra, including easy symbolic notation. Addition; subtraction; multiplication; division; simple fractions; simple equations of one unknown quantity, and easy problems.

Geometry. Experimental Geometry, as contained in the following schedule, with easy extensions:—Bisection of angles and of straight lines, construction of perpendiculars to straight lines, construction of an angle equal to a given angle, construction of parallels to a given straight line, simple cases of the construction from sufficient data of triangles and quadrilaterals, division of straight lines into a given number of equal parts, or into parts in any given proportions.

Mathematics, Grade I.

Algebra. A fuller treatment of the Algebra prescribed for Preliminary Mathematics, together with indices, factors, greatest common measure, least common multiple, fractions, ratio, proportion, equations of one and two unknowns, quadratic equations, the solution of problems involving the use of the above, graphic representation of simple algebraic expressions, and its application to the solution of easy problems. The application of logarithms to arithmetical calculations.

Geometry and Trigonometry. The substance of the first three books of Euclid, and easy deductions therefrom, treated in accordance with the recommendations contained in *The Teaching of Elementary Mathematics.* (Report of the Committee appointed by the Mathematical Association.)

Note.—The Examination Paper in Geometry shall contain questions on Practical and Theoretical Geometry, and candidates must satisfy the examiner in both branches of the subject.

The trigonometrical functions and their mutual relations. The solution of right-angled triangles, and easy topographical applications. The use of logarithmic tables.

Mathematics, Grade II.

Geometry. The substance of Euclid's Elements, Books I., II., III., IV., V., VI., and XI., 1 to 21, with easy deductions, treated in accordance with the recommendations contained in *The Teaching of Elementary Mathematics.* (Report of the Committee appointed by the Mathematical Association.)

Algebra. More advanced treatment of the work prescribed for Grade I., together with involution, evolution, surds, the elements of the theory of equations, progressions, permutations and combinations, the binomial theorem, logarithms, exponential and logarithmic series, undetermined co-efficients, partial fractions, graphical illustrations and problems.

Trigonometry. More advanced treatment of the work prescribed for Grade I., together with addition formulæ for multiple and sub-multiple angles, formulæ for the transformation of products into sums and differences and *vice versa*, elimination, identities, limits, inverse notation, formulæ relating to triangles, the solution of triangles and topographical applications, De Moivre's theorem and its simpler applications, summation of trigonometrical series.

SPECIAL COURSE IN SPHERICAL TRIGONOMETRY.

The elements of Spherical Trigonometry, up to and including the solution of spherical triangles.

MATHEMATICS, GRADE III.

Section I.

Algebra and Analytical Geometry. The elementary theory of equations, determinants. Analytical geometry of the straight line, circle, parabola, ellipse, and hyperbola.

Section II.

Differential and Integral Calculus. Elements of the differential and integral calculus. The fundamental processes of differentiation and integration; successive and partial differentiation; Taylor's theorem, and its application to the expansion of functions; maxima and minima; indeterminate forms; definite integrals. Geometrical applications; tangents and normals, curvature, determination of lengths, areas and volumes; mean values. The solution of differential equations of the first order, and of linear differential equations of the second order, with constant co-efficients.

Courses in Mechanics are also given. They are somewhat technical, and come more properly under the heading of Applied Mechanics.

TECHNICAL EDUCATION IN SOUTH AUSTRALIA.

§32. A considerable amount of attention has been given to Technical Education in South Australia, particularly in connection with Mining. The chief institution is the School of Mines at Adelaide. There is a close connection between this School and the scientific departments of the University of Adelaide. A part of the work for the Fellowship of the School of Mines is carried out at the University. The Associateship of the School is granted for satisfactory work of a more elementary character.

The mathematical classes for these two courses are appended :—

Associate students. All First Year students attend the following class in Mathematics :—

Algebra. Simultaneous equations, harder factors, highest common factor, lowest common multiple, miscellaneous fractions, quadratic equations and problems, simultaneous quadratics, involution, evolution, theory of indices, and surds.

Logarithms. The theory and use of logarithms.

Geometry. Books I. to IV. inclusive (Baker & Bourne's Geometry).

Plane Trigonometry. To the solution of triangles inclusive.

Mensuration. The usual surfaces and solids are treated.

Second Year students in Mechanical and Electrical Engineering attend the following class :—

Co-ordinate Geometry of two dimensions.

Elementary notions and applications of the Calculus.

The Mathematics of the *Fellowship Course* is conducted at the University.

All students of the First Year attend the following class:—

(a) Geometry of the straight line and circle; the theory of proportion and of similar rectilineal figures; elementary solid geometry.

(b) The elements of algebra as far as the binomial theorem.

(c) The elements of trigonometry as far as the solution of triangles.

All students of the Second Year, except those in Metallurgy, attend the following class:—

Algebra, trigonometry, the most elementary portions of analytical geometry of two dimensions, and of the infinitesimal calculus.

Preparatory Instruction. Day and evening preparatory classes are conducted to prepare students who have had only a primary education for the courses mentioned above.

Technical Education in Queensland.

§33. Previous to 1902, Technical Classes were carried on in many of the towns under the control of Local Committees. These received grants from the Treasury. Since 1905, all these classes have been under the control of the Department of Public Instruction, and their work has been supervised by the Inspector of Technical Colleges. The principal institution of this nature in Queensland is the Central Technical College in Brisbane, but the work of the Charters Towers School of Mines deserves special mention. With the exception of these two institutions, the work in all is of an elementary character. It has been spoiled by the insufficient early training of those who attend their classes, a remark which is also applicable to most of the other Technical Colleges and Technical Schools in Australia. The State High Schools, especially the Technical High Schools, will take over much of this work; and the Colleges should soon be able to deal with what lies properly within their sphere.

The syllabus of the mathematical work in these Technical Classes, as prescribed for the different examinations of the Department of Public Instruction, is appended:—

Algebra.

Stage I.—Simple rules. Involution. Resolution into factors. Highest common factor. Least common multiple. Evolution. Simple equations. Fractions. Problems leading to simple equations. Simul-

taneous equations. Linear graphs and the application of graphical methods wherever possible.

Stage II.—Requirements for the University Junior Public Examination.

Stage III.—Requirements for the University Senior Public Examination.

Geometry.

(Text-book, Hall & Stevens' *School Geometry.*)

Stage I.—Use of graduated ruler, set squares, and protractor. Definitions, postulates, axioms. Parts I. and II. Problems and theorems on lines, surfaces, etc, parallels, etc. Exercises on loci. Mensuration examples by construction and proof.

Stage II.—Parts III. and IV.: Problems and theorems on circles, tangents, etc. Geometrical representation of some algebraical formulæ. Simpson's line. Nine-Points' circle. Mensuration of circle, etc. Graphs. Exercises on loci.

Stage III.—Parts V. and VI.: Ratio and proportion. Geometry of planes and solids. Maxima and minima. Inverse points. Poles and polars. Centres of similitude. Transversals, etc. Mensuration of solids. Exercises on loci.

Mensuration.

Lengths. Right-angled triangle; similar figures; chords; circumference and arc of a circle.

Areas. Rectangle; parallelogram; triangle; quadrilaterals; rectilineal figure; circle; sector of a circle and segment of a circle; Simpson's rule; similar figures.

Volumes. Rectangular parallelopiped. Parallelopiped; prism; cylinder. Segments of a right circular cylinder; ring. Pyramid; cone. Frustum of a pyramid or cone. Wedge. Prismoid. Sphere. Zone and segment of a sphere. Irregular solids. Similar solids.

Areas of the Surfaces of Solids. Plane surfaces; right circular cylinder; segments of a right circular cylinder; ring; right circular cone; frustum of a right circular cone; sphere; zone of a sphere; segment of a sphere.

Trigonometry.

Stage I.—Trigonometrical ratios. Ratios of 0°, 30°, 45°, 60°, 90°. Simple heights and distances. Simple identities. Graphs of simple trigonometrical functions. Logarithms and the use of tables. Memorising of rules for the solution of triangles. Applications of logarithms to the solutions.

Stage II.—Circular measure. A + B, and S + T formulæ and identities dependent thereon. Deduction of formulæ for the solution of triangles. Properties of triangles. Solutions of trigonometrical equations. Dip of the horizon.

Stage III.—Exponential and logarithmic series. Inverse circular functions and their graphs. De Moivre's theorem. Summation of series.

Expansions of trigonometrical functions of simple and multiple angles. Hyperbolic functions and their graphs.

Differential and Integral Calculus.

Elementary parts of plane analytical geometry so far as to include the equations and fundamental properties of the conic sections, and a general course in the Differential Calculus and Integral Calculus.

In the Charters Towers School of Mines there are three Mathematical Classes:—

Preparatory Mathematics.

Mathematics I., whose syllabus includes Algebra, Geometry and Trigonometry.

Mathematics II., whose syllabus includes Elementary Analytical Geometry; Differential and Integral Calculus; Spherical Trigonometry.

Technical Instruction in Western Australia.

§34. A Technical College was established in Perth in 1900 under the Department of Public Instruction. It progressed rapidly and did much to prepare the way, at any rate on the technical side, for the new University of Western Australia. There are also branch institutions in Kalgoorlie and other important mining centres.

The Mathematical Work at the Perth Technical School is described below:—

The mathematical classes provide the necessary instruction for students in trade classes, for students taking courses in Engineering, and for students reading the subject as a University course.

For students in *trade classes*, a course of instruction in arithmetic and mensuration is given dealing particularly with practical problems. A more general course deals with arithmetic and mensuration, algebra to quadratic equations, and the simple geometrical properties of the straight line, rectilineal figures and the circle.

A course in practical mathematics deals with the solution of problems in mensuration, statics, dynamics, hydrostatics, and heat, requiring only arithmetic or simple algebra.

Preparatory classes in arithmetic, algebra, and geometry lead up to the regular First Year work of the School.

The higher courses are arranged as First, Second and Third Year Courses in Pure Mathematics, and a One-Year Course in Applied Mathematics.

Details of subjects:—

Pure Mathematics.

First Year.

Algebra, to the binomial theorem.

Trigonometry, to the solution of triangles.

Geometry of the straight line, circle and similar figures, and Solid Geometry, as in Hall & Stevens' *School Geometry*, Parts I.-VI.

Second Year.

Higher Algebra, including elementary theory of equations, convergency and divergency of series, probability, partial fractions, determinants and elimination, exponential and logarithmic series, imaginaries, Argand's construction for complex numbers.

Higher Trigonometry, De Moivre's theorem, roots of unity, expansions of sin x, cos x, tan x, exponential values of sin x, cos x, hyperbolic functions, Gregory's series.

Infinitesimal Calculus, including elementary differential equations.

Analytical Geometry of the straight line, circle and other conic sections.

Third Year.

Analytical Geometry of two dimensions; elements of the Analytical Geometry of three dimensions.

Geometrical Conics.

Infinitesimal Calculus, including elementary differential equations, elements of elliptic functions, harmonic analysis, definite integrals, frequency curve, applications to statistics.

Applied Mathematics.

This course includes Statics, Dynamics and Hydrostatics, treated with the aid of the Calculus.

Technical School Diplomas.

Students taking Engineering Courses are required to take the First and Second Year Courses as above, and for other Technical School Diplomas, the First Year Course.

At the Branch Schools the work is mainly that required for Trade Classes.

Technical Education in Tasmania.

§35. There are five Technical Schools in Tasmania. In one case the curriculum is based upon the syllabus issued by the English Board of Education, South Kensington, under whose auspices examinations are conducted, but, in addition to this, there are individual students who receive instruction under the syllabus of the University of Tasmania, for the Junior and Senior Public Examinations, and the First Year in Arts.

In the remaining four cases, the scope of the work is determined by the syllabus for the Public Examinations named above.

CHAPTER IV.

MATHEMATICS AT THE TEACHERS' COLLEGES.

§36. Up to about 1900 the teachers in the Primary Schools throughout Australia almost without exception obtained their training on the pupil teacher system. After serving for four years in this capacity, a limited number of the pupil teachers would be admitted to courses of training in a Central Teachers' College; but many of the assistant teachers would start their work in the schools without further training. Teachers appointed to schools in the University towns were, and still are, in the habit of attending the Evening Classes in Arts, which some of the Universities have arranged, chiefly for their benefit, and there is a strong and persistent demand from them for fuller provision of Science Classes and Laboratory Instruction in the evening. These conditions will probably always remain: for a large number of the students will be unable to take the full University Course during their attendance at the Teachers' Colleges; but the increase in the number of State Secondary Schools, and the foundation in all the States but one of well-equipped Teachers' Colleges, have greatly changed the position of affairs, so far as the training of the Primary Teachers is concerned. The system of pupil teachers is now practically abolished in almost all the States, and the candidates for positions as teachers in the schools are entering the Teachers' Colleges of the Education Departments better prepared to undergo the courses of training there provided.

For teachers in the Secondary Schools—public or private—a University degree has been in the past, and still remains, an almost indispensable qualification. In addition to the regular University curriculum in Arts or Science that may be taken, it is in all cases recognised to be desirable, and in some cases insisted upon by the Regulations for Registration, that special training in the Theory and Practice of Education be included in the preparation for the work of the school. Further, in at least one State a fair number of travelling scholarships enable the best of those candidates for the teaching profession to enjoy a year or more in Europe or America at the chief institutions for the Training of Teachers, or in special study at the Universities.

In describing the work of the Teachers' Colleges it will again be convenient to take the different States separately.

THE TRAINING OF TEACHERS IN NEW SOUTH WALES.

§37. The pupil teacher system was wholly discontinued in 1905, and the Teachers' College in Sydney was founded in 1906 for the training of State School Teachers and others who might desire to take advantage of the courses of instruction given therein. The College provides a variety of courses of training, varying in length from six months to four years. The ordinary College Course is the two-years' course, which qualifies for teaching in the classes of the Primary School. A short course of six months is in operation for teachers qualifying for work in the small rural schools. A one-year course is also provided for teachers who only aspire to the third-class certificate of the Department. About 150 students enter the regular course each year: and about 250 in addition take one or other of the shorter courses which are included in the College curriculum.

The qualification for entrance to either of the short courses is a pass at the Intermediate Examination, or at some equivalent examination. For entrance to the regular College Course of two years, the Leaving Certificate, or its equivalent, is to be required. At present that standard is not demanded. For entrance at the beginning of 1914 a special examination based upon the Third Year's work in the High Schools has been held.

The regular students of the College who have reached the standard of the Matriculation Examination in the Faculties of Arts or Science are encouraged to attend the University Classes, instead of those at the College in the subjects of their course. They are admitted to these classes without fees. Those who do satisfactorily at the University in their first two years have their College Scholarships continued, so as to enable them to graduate in Arts or Science. The staffs of the High Schools will be chiefly recruited from students of the Teachers' College who have graduated at the University in this way.

In addition to these courses a one-year course is provided at the College for graduates of the University who have not entered in the regular way upon the course of training. This class is exclusively professional and qualifies for the second-class certificate of the Department.

Further, special provision is made for the Training of Teachers for Secondary Schools. Graduate students of the College take the courses required for the University Diploma in Education or similar courses at the College itself. Candidates for this Diploma must have graduated in Arts or Science before admission to the course. The special work for the Diploma can be completed in one year by those who are able to devote their whole time to it. The requirements of the course are as follows:—

Lecture Work: I.—A first course in Philosophy or Education.
II.—A higher course in Education.
III.—A course in Principles of Teaching.
IV.—A course in School Hygiene.

Practice Work: I.—Continuous practice—from 8 to 10 hours per week.
II.—Observation and Discussion of Lessons—from 2 to 4 hours per week.

Some instruction in the methods of teaching mathematics is given by one of the Lecturers in Mathematics in the Course on the Principles of Teaching.

Practice Schools are associated with the College for Primary and for Secondary work. The Principal is also Professor of Education at the University, and the work of the College is carried on in co-operation with the University, so far as possible.

§38. Particulars of the mathematical work in the various College Courses are given below:—

1. Six Months' Course for Teachers in Small Schools.

This course includes the following mathematical work:

Compulsory Section. An easy course in Arithmetic.

Optional Section. A course in Algebra up to simple equations. A course in Practical Geometry.

2. One-Year Course for Teachers in Small Schools.

The purpose of the mathematical course for these students is to develop a correct attitude towards the aim, matter and method of such mathematical teaching as is required in schools under one teacher.

The course is chiefly professional. Sufficient academic work, however, is given to enable students to handle the problems of the Primary School Syllabus, and to see the required mathematics in their correct perspective. Chief attention is devoted to Arithmetic. Lectures are delivered on Experimental Geometry.

The course includes:—Detailed interpretation of the Syllabus; Various methods of teaching the different sections; Objective material, use and limitations; Relation of concrete and abstract arithmetic:

Relation between oral and written arithmetic in the various stages; Nature and source of problems; Typical programmes of work; Use of text-books; Distribution of time.

Demonstration Lessons. Demonstration lessons on the following topics are given to illustrate the course:—Beginnings of number work; Use of counters; Subtraction; Multiplication table; Weights and measures; Fractions, vulgar and decimal; Oral arithmetic; Experimental study of area or volume.

3. Regular Two-Year Course.

First Year.

Every student of the First Year must take the following mathematical class:—

Arithmetic. There is no set academic work in Arithmetic; one hour per week for each term is given to the method of teaching Arithmetic. Amongst others the following topics are discussed:—

Brief historical review; Reasons for teaching arithmetic; Present tendencies; Real applied problem movement; Nature and source of problems; Use and limitation of objective material; Place of oral and written work in the various classes; Topical-spiral treatment; Various methods of teaching sections of Arithmetic; The beginnings of number work; Plan and purpose of mechanical work; Teaching of processes; The Primary School curriculum.

Geometry. Brief historical sketch of the development of Geometry; Egyptian Geometry; Greek Geometry; The work of Euclid; The reform movement in the teaching of Geometry; The present attitude towards the subject; The nature and place of definition, axiom, postulate, proof; Experimental and demonstrational Geometry; The relation of solid and plane Geometry; Congruency, similarity, and homology of figures and their applications; Extension to Trigonometry.

A short course in solid Geometry.

Algebra. Those topics in elementary Algebra which require special treatment in class teaching are discussed, including the following:—Relation of Algebra to Arithmetic; Literal Arithmetic; Formulæ from Arithmetic and Mensuration; Notion of a negative; Operations involving negatives; The equation; Solution of problems by means of equations; Factors and their applications; Indices, logarithms, calculations with logarithm tables and slide rule; Irrationals, numerical evaluations, using tables; Ratio, proportion, variation and their applications; Notion of a function; Graphical representation of the variations of a function; Discussion of roots of equations, maximum and minimum values from graph.

Trigonometry. The purpose of the course is to investigate those cases of the solution of triangles which are used in obtaining heights and distances.

Notion of an angle; Instruments in common use for measuring angles; Sine, cosine, and tangent for acute angles; Reading sine and

tangent tables; Solution of right-angled triangles; Use of four-figure tables; Extension of definitions of sine, cosine, and tangent to angles between 90° and 180°; Relations between the sides and angles of a triangle; Area of triangle; Notion of triangulation and application to simple surveys; Heights and distances in more than one plane.

Second Year.

The mathematical work in the Second Year is optional. The programme for the class is as follows:—

Mathematics. The course includes Algebra, Trigonometry, Co-ordinate Geometry, Mechanics, Infinitesimal Calculus, History and Method of Elementary and Secondary School Mathematics.

Throughout the academic work the professional aspect is kept prominently in view.

Algebra. Ratio, Proportion, Variation, The Progressions (Arithmetical, Geometrical, Harmonical), Permutations and Combinations, Mathematical Induction, Binomial Theorem.

Trigonometry. Continuation of First Year Course, including angles of any magnitude, sin (A $\pm$ B), cos (A $\pm$ B), tan (A $\pm$ B), sin A $\pm$ sin B, cos A $\pm$ cos B. Relations between sides and angles of a triangle, Solution of Triangles, Heights and Distances, Circular Measure, De Moivre's Theorem, Simple Trigonometric Series.

Infinitesimal Calculus. A course on the processes and applications of the Differential and Integral Calculus. Graphical methods are freely used where advantageous. The course is designed particularly to complete the work in Geometry, Mechanics and Trigonometry.

Mechanics. The aim of the course is to teach the fundamental mechanical principles. Simple course of experiments illustrating the following:—Composition and resolution of forces; Principle of levers, pulleys, inclined plane; Friction; Motion of falling bodies; Circular motion; Principle of Archimedes; Hydraulic press and pump; Atmospheric pressure; Easy practical calculations within this range.

Reading. Students do directed reading of mathematical works in the College library, as well as in the following text-books:—*Teaching of Mathematics in the Elementary and the Secondary School*—J. W. A. Young. *History of Mathematics*—Fink, translated by Beman & Smith.

The Training of Teachers in Victoria.

§39. The teachers in the Primary Schools of Victoria now receive their training in the Teachers' College at Melbourne. The Principal of this College is also Lecturer in Education at the University, and there is as close co-operation as possible between the University and the College, so that a number of the students of the latter attend the University classes in some subjects. Indeed, those preparing to become teachers in the Secondary Schools of Victoria

receive almost all their instruction at the University. Under the regulations now in force, every teacher in a Secondary School in Victoria must possess the University Diploma in Education, or an equivalent qualification. All candidates for that Diploma must have passed through at least two years of some degree course, and must have devoted a final year to special work in Education. As a matter of fact, many of those working for the Diploma take their B.A. or B.Sc. degree before entering upon the special course in Education for the Diploma.

The students entering the College are divided into the following groups:—

(*a*) Those taking the three years' course for the Secondary Certificate.
(*b*) Those taking the one year's course for the Primary Certificate.
(*c*) Those taking the two years' course for the Infant Teachers' Certificate.
(*d*) Those taking a six months' course leading to employment in the Primary Schools.
(*e*) Those taking courses in Domestic Arts and Manual Work.

Those accepted for Class (*a*) above must have passed the Senior Public Examination, or an equivalent examination. The number admitted to this class is limited to 15 each year. Their course of training is the same as that for the Diploma in Education at the University, together with some special subjects. The first two years are spent in regular attendance upon University classes in Arts or Science. Having passed the First and Second Year's Examinations in Arts and Science, they are then admitted to the special University courses in Education for the Diploma. These courses include lectures on the Theory of Education, with special reference to the methods of teaching the various subjects. With regard to Mathematics the course contains the following:—

i. Special Methods of teaching Arithmetic, Algebra, Geometry and Trigonometry.

ii. A short History of Elementary Mathematics.

iii. General Considerations on the Teaching of Mathematics.

Further, students are required to teach 120 hours under supervision; to attend lessons given by members of the College staff; and also to criticise lessons. Part of this practice is obtained in the Primary Schools, and part in the special Secondary Practising School attached to the Teachers' College, and other schools.

There are about 50 to 60 regular students of the College each year preparing for this Diploma, and in addition about the same number of University students are qualifying for it, in order that they may be enabled to take up work in the Secondary Schools outside the Department's control.

The authorities of the College are entitled to nominate six of those who distinguish themselves in this course for a further year's work.

Those accepted for Class (*b*) must have passed the University Matriculation Examination. About 40 are admitted annually to this one-year course for the Primary Certificate. All their time is devoted to professional work. Instruction is given in methods of teaching elementary mathematics. During their year at the College a number of these students attend some University classes, and the College authorities are entitled to nominate ten members of this class for an additional year to be spent altogether at the University.

Those accepted for Class (*c*) must have passed the Junior Public Examination, or have obtained the Intermediate Certificate. The only mathematical work in their course is extremely elementary. About 12 have been admitted to this class in 1914.

The six months' course referred to in Class (*d*) is open to those who have passed the Senior Public Examination and desire to qualify for appointments in the elementary schools. About 20 students are admitted to this class, and they have special instruction in teaching Arithmetic, and such parts of Algebra and Geometry as are studied in these schools.

Every alternate year 30 students are admitted to the College to undertake a three-years' course as indicated in Class (*e*). The applicants for admission must have passed the Senior Public Examination. This course does not include any special mathematical work.

Further, 20 teachers are selected annually, chiefly from primary schools in the country, who show that they could profit by University instruction and prepare themselves for more important work. These teachers are temporarily attached to schools in Melbourne, their duties being so arranged that they shall be able to attend the regular University classes and follow the course for the Diploma of Education.

The Training of Teachers in South Australia.

§40. The following is an outline of the course of training for teachers in the Schools of South Australia under the Education Department in Adelaide:—

1. At the age of 14 the future teachers enter the Adelaide High School. They remain there for three years and receive a general education. At the end of this period the majority will have passed the Senior Public Examination of the University of Adelaide; practically every student passes in Arithmetic and Algebra; a large number also pass in Geometry and in Trigonometry.

2. The students in training now become "Junior Teachers," and spend 1-2 years in Primary Schools, devoting practically all their time to their teaching work.

3. Thereafter they enter the Teachers' Training College. Here the students attend University Classes in various subjects, a certain amount of freedom of selection being permitted. About 20% take up what is called First Year Pure Mathematics, an elementary class at about the standard of the Higher Public Examination in Algebra, Geometry and Trigonometry.

The students also attend several Training College Lectures, among these being a course in the Principles of Teaching. This course deals with the methods of teaching the primary school subjects; about 20% of the total available time (80 hours) is devoted to Arithmetic. They also spend one morning per week at actual teaching in the Primary Schools.

The students who leave the Training College at the end of one year become Infant and Primary School Teachers.

Those who have shown special ability both as students and as teachers are permitted to remain a second year, or even a third year, at the University. These students invariably take up a certain amount of Mathematics, usually attending Second Year Pure Mathematics, as they will in most cases have already taken the First Class. Some also take the Elementary Applied Mathematical Class. It is not uncommon for Mathematics, Physics and Chemistry to form the bulk of their work.

Such students have teaching practice as before; also weekly discussions on the Methods of Teaching. Five of these discussions,

out of a total of twenty-five, deal with Elementary Mathematics.

The majority of these students become High School Teachers.

The Training of Teachers in Queensland.

§41. Queensland does not yet possess any special College for the Training of Teachers. For the State Primary Schools the pupil teacher system still holds, though this year arrangements are being made for its being gradually replaced by a more satisfactory system. Twenty scholarships are to be thrown open every year to such pupils in their final year in the State High Schools as desire to become teachers. The holders of these scholarships will attend the classes of the University of Queensland, and their studies will be supervised by the Lecturer in Education at the University. No special treatment of Mathematics is prescribed for their course, but most of them will take the First Year Class in Mathematics.

In the Grammar Schools the staff consists principally of University graduates. The High Schools also aim at a University degree as an almost indispensable qualification for their teachers.

The Training of Teachers in Tasmania.

§42. Under the scheme for the Training of Teachers, which is being introduced in Tasmania, candidates will be admitted as Junior Teachers at a minimum age of 15 years, on a competitive examination at about the standard of the Junior Public Examination. They will then attend the classes of one of the State High Schools for two years. At the end of this period the majority of them should be able to pass the Senior Public Examination and matriculate at the University. The next year is to be spent in teaching in selected schools. Thereafter they will enter the Training College in Hobart, the minimum age at entrance being 18 years. Students who have passed the matriculation examination will attend the University classes for one, two, or three years. Those who have not reached the matriculation standard will attend the College Classes for one year in suitable subjects. All will receive professional training at the College.

The Training of Teachers in Western Australia.

§43. The pupil teacher system has now been in great part abolished, though traces of it still survive in some of the country schools. The Primary Teachers receive their training in the Train-

ing College of the Education Department. In this College there is a two years' course for the fully-trained teacher, and also a six months' course for the teacher whose work will lie in the small country schools. The College Curriculum includes two classes in Mathematics. That of the First Year is taken by all the regular students; the second year course is optional, but in practice it is taken by almost all the men students, and by about 25 per cent. of the women students. The subjects treated in these courses are as follows:—

First Year Course. Arithmetic, Algebra and Geometry, up to about the standard of the Junior Public Examination.

Second Year Course. Algebra, Geometry, and Trigonometry, up to about the Senior Standard.

Special attention is given in both courses to graphical work.

CHAPTER V.

MATHEMATICS AT THE ROYAL AUSTRALIAN MILITARY AND NAVAL COLLEGES.

§44. There are two institutions in Australia for the early training of the officers of the Military and Naval Forces of the Commonwealth, the Royal Australian Military College at Duntroon, in the Federal Territory and close to the site of the new Capital, and the Royal Australian Naval College, at present in temporary quarters at Geelong near Melbourne, later to be situated at Jervis Bay, the port of the Federal Territory, 80 miles from Sydney. Both of these Colleges are under the control of the Defence Department of the Commonwealth of Australia.

The first is modelled somewhat upon the lines of West Point College in the United States. The cadets enter at the age of 16 to 19, and receive a liberal education embracing both Military and Civil subjects. The Civil subjects comprise Mathematics, Physics, Chemistry, English, History, and Modern Languages (French and German). Mathematics is a compulsory subject in the Entrance Examination, and occupies a prominent position in the College Course.

After satisfactorily completing the four years' course in the College, the cadets receive the rank of Lieutenant and spend one year in England or India attached to British regiments. They then return to Australia to occupy positions in the permanent military forces. The number of cadets admitted each year is about 40, including 6 who come from New Zealand. Promotion to the succeeding years is dependent upon satisfactory work during the preceding year, and upon the results of the examinations at the close of each course.

The Naval College has been founded for the training of the Cadet Midshipmen who will later join the ships of the Royal Australian Navy. The training will closely resemble that given in England at Osborne and Dartmouth. But the Australian Naval College is designed to give a four-year course in the one institution, whereas in England a cadet spends two years at Osborne and a further two years at Dartmouth. Candidates must be 13 in the year in which they are examined for entrance. The first batch of

Cadet Midshipmen began their studies early in 1913. It is intended to admit about 30 annually.

The Royal Australian Military College.

§46. We shall now describe the mathematical work in this College and the requirements at entrance.

The competitive examination for entrance to the College consists of two Divisions. Division I. is compulsory for all candidates. It contains five papers, one of them being in Elementary Mathematics (Arithmetic, Algebra and Geometry). The standard in these subjects is roughly that of the Junior Examination. Of the four papers in Division II., the candidate may take only two. If he choose the paper in Mathematics, he is examined in Algebra, Geometry, and Trigonometry up to the Solution of Triangles. The work in Algebra covers the Arithmetical and Geometrical Progressions, Surds, Indices, and Logarithms. In Geometry it includes the substance of Euclid, Book IV., and the Theory of Proportion and Similar Figures.

First Year Course.

In this year 216 hours are given to Mathematical Lectures. The subjects studied are Algebra, Geometry, Trigonometry, Elementary Differential and Integral Calculus, and Elementary Statics and Dynamics. In the programme for each subject there is an obligatory and a voluntary section. The details of the work are as follows:—

Algebra. Obligatory: Graphical solution of simultaneous equations; approximate numerical calculations; approximate numerical solution of equations; theory of quadratic equations; arithmetical and geometrical progressions; indices; simple cases of permutations and combinations; binomial theorem for a positive integral index; theory and practical use of logarithms; explanation and use of the slide rule.—Voluntary: Convergency and divergency of series; exponential theorem; logarithmic series and the calculation of logarithms.

Geometry. Obligatory: Theory of proportion and similar figures.—Voluntary: Solid Geometry; the straight line and plane.

Trigonometry. Obligatory: Trigonometrical ratios of an angle of any magnitude; functions of compound angles; easy trigonometrical equations; use of trigonometrical tables; solution of triangles; applications to heights and distances, range-finders, etc.—Voluntary: Transformation of sums and products; functions of small angles (range-finder formula, angle subtended $= \frac{h \times 1146}{R}$); solution of trigonometrical equations (*e.g.*, elevation for projectile to hit a given point $\frac{gx}{2V^2} \sec^2 a - \tan a + \frac{a}{x} = 0$); inverse functions.

Calculus. Obligatory: Graphical representation of simple algebraic and trigonometric functions, and their rates of change; applications to velocity, flow of water from a tank, etc.; differentiation and integration of the simplest functions; applications to maxima and minima.—Voluntary: Differential co-efficients of more complex functions; simple applications—maxima and minima (*e.g.*, maximum range of a projectile on an inclined plane); integration of simple functions; application to areas of simple curves.

Dynamics. Obligatory: Principles of dynamics—acceleration, force, mass; uniformly accelerated motion in a straight line; momentum (recoil of gun MV = mv); work, power (energy of shot $\frac{1}{2}$ mv^2 derived from the powder); parallelogram laws; projectiles; uniform motion in a circle (tension in a belt, governors, etc.); simple harmonic motion (motion of piston and crank); pendulum.—Voluntary: Collision; angular velocity (gearing); rotation of a body about a fixed axis; moments of inertia (fly-wheels); compound pendulum; velocity of centre of mass of a system of particles.

Statics. Obligatory: Composition and resolution of forces in one plane treated algebraically and graphically; moments; couples; equilibrium of a body under forces in one plane; friction; centres of mass; applications to machines (levers, pulleys, toothed wheels, cranes, etc.). —Voluntary: Examples of calculation of stresses in frameworks consisting of a few bars (roofs, loads on bridges, etc.).

Second Year Course.

In the Second Year the hours of instruction in Mathematics are the same as before. The subjects of study are Algebra, Geometry, Plane and Spherical Trigonometry, Astronomy, The Infinitesimal Calculus, Statics and Dynamics, Elementary Hydrostatics and Hydrodynamics. The details of the work are as follows:—

Algebra. Obligatory: Partial fractions; convergency and divergency of series; exponential theorem; logarithmic series and calculations of logarithms; simple theorems in probability.

Geometry. Obligatory: (Solid) The straight line and plane. (Analytical) The straight line and circle.—Voluntary: (Analytical) Parabola; ellipse; hyperbola.

Trigonometry (*Plane*). Obligatory: Small angles; inverse functions; solution of trigonometrical equations; small errors; effect of small errors in surveying; effect of error of elevation on trajectory of bullet.

Trigonometry (*Spherical*). Obligatory: Solution of spherical triangles—Applications to surveying and astronomy.

Astronomy. Obligatory: Phenomena depending on the motions of the earth; time; determination of latitude and longitude; astronomical instruments—Voluntary: Correction of instrumental errors: the planets; Kepler's laws.

Calculus. Obligatory: Differentiation of functions; maxima and minima; successive differential co-efficients; theory of proportional parts, applications to curves; integration of simple functions; areas; volumes; Taylor's Theorem; expansion of common functions in series. —Voluntary: Differential co-efficients of functions of two variables; maxima and minima of functions of two variables; approximate numerical evaluation of integrals.

Dynamics. Obligatory: Collision; angular velocity and acceleration (gearing); rotation of a body about a fixed axis; moments of inertia (fly wheels); compound pendulum; velocity of centre of mass of a system of particles.—Voluntary: Application of the calculus to motion of a particle in a straight line and plane curve; effect of air resistance on a bullet; elementary cases of motion of a rigid body in one plane.

Statics. Obligatory: Centre of mass; calculations (numerical and graphical) relating to tackle, sheers, derricks, etc., stresses in frame-works, such as simple roof trusses and bridges; stresses in a gun; maximum stresses permissible.—Voluntary: Forces in three dimensions.

Elementary Hydrostatics and Hydrodynamics. Obligatory: Pressure at a point in a liquid at rest; pressure on a plane area; resultant pressure on any area; centre of pressure; applications to tanks and reservoirs.—Voluntary: Elementary cases of flow of a liquid; pressure in a moving fluid; pressure on a surface moving in a fluid (aeroplanes).

Third Year Course.

In the Third Year less time is given to Mathematics, the hours of instruction being only 72. The subjects of study are:—The Infinitesimal Calculus, The Theory of Errors, Differential Equations, Statics and Dynamics. The details of the work are as follows:—

Calculus. Obligatory: Differential co-efficients of functions of two variables; approximate numerical evaluation of integrals; mean values.

Theory of Errors. Obligatory: The probability integral; applications of the theory of errors, particularly to gunnery.

Differential Equations. Obligatory: Ordinary equations of the first order and degree; linear equations.—Voluntary: Solution in Series.

Dynamics. Obligatory: Application of the calculus to motion of a particle in a straight line and plane curve; effect of air-resistance on a bullet; elementary cases of motion of a rigid body in one plane.—Voluntary: Elementary cases of motion in space; gyrostats.

Statics. Obligatory: Catenaries; forces in three dimensions.

This completes the mathematical work at the College. No time is allotted to this subject in the Fourth Year. The teaching is guided particularly in two directions, the one leading to surveying and astronomy, the other to the mechanical applications. With the experience of the first few years it is possible that some changes will be made in the curriculum. Probably more Applied Mechanics will

be introduced. Further, it may be found advisable that all cadets intending to do Engineering Work shall take the full course with more voluntary work, while for others the compulsory sections may have to be cut down.

The Royal Australian Naval College.

§46. We pass to the Naval College, its Entrance Examination and Courses of Study.

With regard to the Entrance Examination, the English practice is followed. All candidates appear before a Committee of Selection. Those who are recommended by the Committee then undergo the Qualifying Examination. The subjects of this written examination are English, History, Geography, Arithmetic, and Geometry. In the regulations for the Geometry paper it is stated that formal Euclidean proofs of the theorems and constructions will not be required. The work of both these mathematical papers is very elementary, the candidates being only 13 years of age.

The full course at the College lasts for four years. The subjects of the Curriculum are as follows:—

Mathematics. Arithmetic, Algebra, Geometry, Trigonometry (Plane and Spherical), Algebraical Geometry, Differential and Integral Calculus.

Physics. Hydrostatics, Theoretical Mechanics, Heat, Optics, Magnetism, Electricity; Applied Mechanics, Applied Electricity.

Chemistry.

Engineering, with Workshop Practice and Mechanical Drawing.

Seamanship, with Gunnery in the Training Cruiser.

Navigation, with Nautical Astronomy.

English.

French.

German.

History, including Naval History.

Geography.

Religious Instruction.

Gymnasium and *Drill.*

The details of the mathematical work of the First Year are appended. These are sufficient to show the trend of the course. The programmes for the following years will not be settled till after each year's experience has shown what appears to be the best choice.

First Year Mathematics.

Arithmetic.

Elimination of faulty methods in simple calculations.
Methods of checking.
Meaning of results to a certain number of figures.
Useful compound quantities (British system).
Metric system. Decimal fractions.
Prime factors. H.C.F. L.C.M.
Tests of divisibility.
Square root, by calculation and by tables.
Tables of reciprocals.
Averages.
Ratio, Proportion, Percentages.
Mensuration formulæ.
Problems based on data obtained in the Mathematics workshop.

Algebra.

Signs and symbols.
Substitution in identities and formulæ.
Simple equations.
Co-ordinates. Graphs of straight lines, parabolas, hyperbolas. The circle, centre at origin. Interpolation. First notions of slope.
Simultaneous equations.
Multiplication and Division, with numerical checks.
Factors of quadratic expressions.
H.C.F. L.C.M. Fractions.

Geometry.

The accurate use of instruments.
Revision of the fundamental facts connected with—
- Angles at a point. (Scale of chords.)
- Parallel straight lines.
- Angles of a triangle; of a polygon.
- Properties of triangles. (Locus of the vertex under given conditions. Station Pointer.)
- Congruent triangles.
- Perpendiculars.

Pythagoras' Theorem.
Ruler and compass constructions, with proofs, verifications, and derived exercises.
Theorems connected with—
- Parallelograms.
- Loci.
- Areas of rectilinear figures.
- The circle.

NOTE.—The above syllabus is intended primarily to deal with Plane Geometry, but every opportunity is taken to introduce three-dimensional work.

Trigonometry.

The use of tables of tangents to check the results of practical work in heights and distances.

The use of sine, cosine and tangent in the solution of right-angled triangles.

Traverse Tables. The solution of any triangle by division into right-angled triangles. Vector work.

Graphs of sine, cosine and tangent.

The simpler formulæ.

Simply-periodic motion.

Mathematics Workshop.

Much of the work usually done in a First Year Course of Physics is here done by the mathematical staff in their own workshop.

Areas of triangles and rectangles.

Volumes of rectangular solids.

Determination of π

Mensuration of circle, cylinder, pyramid, cone, sphere. (Frequent reference to "constant" and "variable;" also, for example, the volume of a cylinder is a "function" of its height and of the radius of the base.)

Oblique solids.

Areas of irregular surfaces by mean-ordinate methods.

Areas, volumes, weights of irregular bodies. Applications to machine details, etc.

Displacement methods.

Parallelogram and triangle of forces. Resolution of forces graphi cally and by traverse tables.

Moments, couples, torque, parallel forces.

Centre of gravity. Volumes of solids of revolution.

Lever, pulley, inclined plane, wedge, screw, train of wheels, etc.

Pressures in liquids.

Atmospheric head.

Pumps.

Flotation. Principle of Archimedes.

Specific gravity.

Boyle's Law.

Graphs of tabulated results of measurements.

Drawing to scale. Heights and distances. Bearings (theodolite, azimuth compass).

Tracing cloth experiments, including the loci of points (for example, on a connecting rod).

NOTE.—Special attention is paid throughout to the limits of experimental accuracy.

CHAPTER VI.

MATHEMATICS AT THE AUSTRALIAN UNIVERSITIES.

§46. The oldest of the Australian Universities, Sydney and Melbourne, were founded in 1850 and 1853, respectively. Sydney now has a staff of 22 Professors and 112 Lecturers, while the number of its students exceeds 1,400. Melbourne, with 18 Professors and 56 Lecturers, has over 1,200 students. In addition, 98 are attached to the Conservatorium of Music. The total revenue of Sydney in 1912 was £87,000, of which £43,000 was received from the Treasury. In Melbourne the total was £76,000, and of this the Treasury also supplied a large proportion, namely, over £37,000. Adelaide, founded in 1874, follows these two, both in numbers and importance. Two distinguished mathematicians succeeded one another in the Chair of Mathematics in that University, Horace Lamb and W. H. Bragg. The University of Tasmania, founded in 1889, in Hobart, is still much handicapped by small resources. The University of Queensland, founded in 1909, in Brisbane, has an important sphere of influence. Like the University of Western Australia, founded three years later in Perth, its revenue is derived almost wholly from Government Grants. The first receives at present £12,500 per annum, and the other £13,500. The tendency, both in Brisbane and in Perth, is to develop these institutions more as Technical Universities than was the case in the earlier days of Sydney, Melbourne and Adelaide.

The University of Sydney.

§47. The staff of the Department of Mathematics at Sydney at present consists of one Professor, an Assistant-Professor and two Assistant-Lecturers. Some of the work in the Department of Physics supplements the courses in Applied Mathematics. A Chair of Astronomy was founded in 1912, the present occupant being also Government Astronomer for the State of New South Wales.

In the Entrance Examination elementary Mathematics is required from all candidates. The details of the examination requirements have been given on pages 12-13. Courses in Mathematics form a part of the curriculum for the Arts and Science degrees. For the Arts degree (B.A.) a Pass Class in Mathematics used to be compulsory. This regulation has now been abolished, but many Arts students study Mathematics for two years, and those who desire the

degree of B.A. with Honours in Mathematics must complete the Three-year Course for Honours. For the Science degree (B.Sc.) the First Year Course consists of Chemistry, Physics, and two of the following:—Botany, Zoology, Geology, and Mathematics. A frequent combination is the first two, with Geology and Mathematics. Students of the second year drop one subject, and in their third and last year they drop another. Those who take Mathematics in the three years of the Science Course usually combine with it a Three-year Course in Physics. For the degree in Engineering (B.E.) Mathematics is compulsory. The Mechanical, Electrical, and Civil Engineering students take the subject for two years; the Mining Engineering students take only the First Year Course.

A Two-year Course has recently been instituted in Insurance-Mathematics, chiefly for actuarial students and others who desire instruction in the mathematics of statistics.

Astronomy is now an optional subject of the second year in the B.Sc. Course.

The programmes for the mathematical courses in Arts, Science and Engineering are given below:—

There are three classes—Mathematics I., II. and III. Each is divided into three sections—Class A, Class B and Class C. Candidates for the degree of B.A. or B.Sc. with Honours attend the Honours section (Class A) in each year; but it is possible to reach the lowest grade of Honours by specially good work in the second section (Class B) in the three years.

Mathematics I. (First Year).

Class A. This class reads Algebra, Geometry, Trigonometry, Statics and Dynamics, Analytical Geometry of Two Dimensions, and the Elements of the Calculus. Those who enter it are expected to have previously completed the mathematical work required for Honours in the Senior Public Examination or an equivalent course. The class is attended by students in Arts, Science and Engineering.

Class B. This class reads the Elements of the Calculus and Analytical Geometry for two terms, and Elementary Statics and Dynamics for three terms. Members of this class must have done the Pass work of the Senior Examination before entrance or its equivalent. It is the Pass Class for Engineering and Science students in their First Year.

Class C. This class has a course in Algebra, Geometry and Trigonometry, at about the standard of a Pass in the Senior Examination. It

finds a place in the curriculum chiefly for those who have not reached this standard at school, and yet wish to proceed further with Mathematics. Many of those who take it at present are preparing to be teachers in the Primary Schools, and when they have completed this course they proceed to the higher class provided under Mathematics II. (Class C). With the development of Secondary Education in New South Wales, the standard of work in this class will be raised.

Mathematics II. (Second Year).

Class A. This class reads The Infinitesimal Calculus, Differential Equations, Spherical Trigonometry, Analytical Statics, Particle Dynamics, and Elementary Rigid Dynamics. It is attended by the best students of Mathematics I. when they proceed to their Second Year.

Class B. This class follows the above course, omitting Analytical Statics, and doing less work in Differential Equations and Spherical Trigonometry. It is attended by students in Arts, Science and Engineering. All Engineering students, except those in Mining, must attend either this class or Class A in their Second Year.

Class C. This course is for students of Mathematics I. (Class C) who desire to take a Second Year Course in Mathematics. The work is much the same as that of Mathematics I. (Class B).

Mathematics III. (Third Year).

Class A. This class reads Analytical Geometry of Three Dimensions, Rigid Dynamics, Higher Analysis, and some Applied Mathematical subject: *e.g.*, Hydrodynamics, Sound, The Theory of Electricity and Magnetism.

Class B. This class takes the first two of the subjects named under Class A, and in addition Analytical Statics, with Hydrostatics. It is the Pass Class for Science students who take a Three-year Course in Mathematics. It is also attended by Arts students.

Class C. This class is for students of Mathematics II. (Class C) who desire a Third Year Course. They attend the lectures and do the work of Mathematics II. (Class B).

Insurance-Mathematics.

The class in Insurance-Mathematics ranks as a First and Second Year Class, and is an alternative to Mathematics I. and II.

The programme for the First Year Course is as follows:—

Arithmetic and Algebra, Elements of the Theory of Probability, Elements of Analytical Geometry of Two Dimensions and the Calculus, Compound Interest and Annuities Certain, The Construction and Use of Tables, and Graphical Methods.

The programme for the Second Year Course is as follows:—

The Theory of Probability (more advanced), The Theory of Least Squares and Errors, The Theory of Life Contingencies and Calculating Machines.

The number of students in these Mathematical Classes each year is now roughly as follows:—

	Mathematics I.	Mathematics II.	Mathematics III.
Class A	20	15	6
Class B	50	35	6
Class C	50	15	4

THE UNIVERSITY OF MELBOURNE.

§48. The mathematical work in the University of Melbourne is divided between the Professor of Mathematics and the Independent Lecturer in Applied Mathematics. Some of the courses of the Professor of Natural Philosophy are also closely allied to the work of these two Departments. Lectures on Astronomy form a part of the Third Year Course in Natural Philosophy.

Mathematics is a compulsory subject at the Entrance Examination. The details for the different Faculties are given on page 8. A Pass Class in Mathematics used to be compulsory for all candidates for the B.A. degree. In 1913 this regulation was abolished. For the B.Sc. degree the arrangements are somewhat similar to those of Sydney. Those who do not take the First Year Course in Mathematics must study Natural Philosophy, Chemistry, and either Botany or Zoology. For the degrees in Engineering at least two years' mathematical work is required.

The programmes for the mathematical courses are given below:—

Pure Mathematics, Part I.

Pass. This course is analytical. It deals with the Elementary Algebraic, Trigonometric, Exponential, Logarithmic and Hyperbolic Functions, with their Graphs and Derivatives; Maxima and Minima; Elementary Processes of Integration; The Definite Integral as the Limit of a Sum.

Honours. Algebra, Trigonometry, Elementary Analytical Geometry of Two Dimensions, and Elementary Calculus.

One of the divisions of this class must be taken by all Engineering students.

Pure Mathematics, Part II.

Pass. In this course further work is done in Plane Analytical Geometry and the Calculus.

Honours. This class continues the work of Part I. (Honours) in Plane Analytical Geometry and the Calculus, and it begins Analytical Geometry of Three Dimensions.

One of the divisions of this class must be taken by all Engineering students.

Pure Mathematics, Part III.

Pass. The subjects of this course are Solid Geometry and the Calculus, with Differential Equations.

Honours In addition to the subjects for Part II. (Honours), The Functions of a Complex Variable, Fourier's Series and Integrals, Differential Equations and Calculus of Variations are read.

Applied Mathematics.

The subjects of the courses in Applied Mathematics are as follows:—

Applied Mathematics, Part I.

Pass. Elementary Statics and Dynamics, with Hydrostatics.

Honours. A fuller treatment of the subjects of the Pass Class with the Elements of Vector Algebra.

One of the divisions of this class is compulsory for all Engineering students.

Applied Mathematics, Part II.

Pass. Elementary Analytical Statics and Dynamics, with Hydrostatics.

Honours. Analytical Statics, Dynamics of a Particle, Elementary Rigid Dynamics, and Hydrostatics.

One of the divisions of this class must be taken by all Civil and Mechanical Engineering students. The Civil Engineering students must also take a class in Spherical Trigonometry.

Applied Mathematics, Part III.

Pass. Analytical Statics and Dynamics, The Elements of the Theories of Potential, Hydrodynamics, Elasticity and Electricity.

Honours. More advanced work in these subjects.

There is a Final Honours Examination in Mathematics—Pure and Applied. This examination covers the work of the three courses given above. Candidates who have satisfied the other conditions for the B.A. or B.Sc. degrees may obtain these degrees with Honours in Mathematics on the results of this examination.

Very few students in Melbourne take a Three-year Course in Mathematics, and the number who graduate with Honours in Mathematics is small. The following table gives approximately the size of the first and second classes in recent years:—

Pure Mathematics, Part I.—Pass	120
Honours	10
Part II.—Pass	40
Honours	5
Applied Mathematics, Part I.—Pass	40
Honours	10
Part II.—Pass	10
Honours	5

The University of Adelaide.

§49. The Professor of Mathematics at Adelaide was until recently also Professor of Physics. On Professor Bragg's removal to Leeds in 1908 separate chairs were created in these subjects.

Mathematics is a compulsory subject in the Entrance Examination. The details for the different Faculties are given on pages 19-20. Recently a degree in Engineering has been instituted, some of the work necessary being done at the School of Mines.

The following Mathematical Courses are given:—

1. First Year Pure Mathematics.

Algebra, Geometry and Trigonometry, at about the standard of the Higher Public Examination.

This class is compulsory for all Science and Engineering students who have not passed in these subjects at the examination referred to. It may also be taken by Arts students as a qualifying course for their degree, but Mathematics is not a compulsory subject for such students. The average number of students in this class is 25.

2. Second Year Pure Mathematics.

Higher Trigonometry, Plane Analytical Geometry and the Calculus.

This class is attended by Arts, Science and Engineering students. The average number of students in this class is 25.

3. Third Year Pure Mathematics.

Higher Analytical Geometry, Differential and Integral Calculus, with Differential Equations.

This class is attended by Science students and occasionally by Arts students reading for Honours. The average attendance is about six.

4. Applied Mathematics.

The Elements of Statics, Dynamics and Hydrostatics, treated with the aid of the Calculus.

This class is compulsory for Engineering students and is also taken by Arts and Science students. The average attendance is about 20.

5. Spherical Trigonometry and Astronomy.

This is a course for the B.Sc. degree. It is not given every year.

6. Honours Mathematics Class for B.A. and B.Sc.

A course of lectures is given annually in the following subjects:— Analytical Geometry of Three Dimensions, Differential Equations, Analytical Statics and Dynamics, and Elementary Rigid Dynamics. There are usually only one or two students.

The subjects for the Final Honours Examination are:—

(*a*) Analytical Geometry, Infinitesimal Calculus, Analytical Statics, Dynamics of a Particle, Elementary Rigid Dynamics and Hydrodynamics; or

(*b*) Analytical Geometry, Infinitesimal Calculus, Harmonic Analysis, including Fourier's Series and Laplace's Functions.

THE UNIVERSITY OF TASMANIA.

§50. In this University the Professor of Mathematics is also Professor of Physics. Until this year all the work in both subjects has been done by him single-handed, except for some slight assistance in the elementary mathematical class. A Lecturer in Physics has now been added to the staff.

Mathematics is a compulsory subject at entrance. The details for the different Faculties (Arts, Science, and Laws) are given on pages 26-27.

The following mathematical classes have been held:—

A. (*First Year Arts.*)

Geometry, Algebra and Trigonometry, at about the Senior Standard. For the better students additional work is given in Higher Algebra and Trigonometry.

This class has to be taken by all Arts students some time during their course, unless they do specially good work in some other subjects.

B. (*First Year Science and Second Year Arts.*)

Graphical Methods and the use of Tables, Elementary Calculus, Analytical Geometry, and Trigonometry. The better students do more advanced work in Algebra and Analytical Geometry. This class is compulsory for Science students.

C. (*Second Year Science and Third Year Arts.*)

Vector Methods as applied to Geometry and Mechanics, Elementary Analytical Geometry of Three Dimensions, and Analytical Statics with Hydrostatics. The better students do additional work in the Calculus and Analytical Geometry.

D. (*Third Year Science.*)

Differential Equations, Spherical Trigonometry and Astronomy, Elementary Particle and Rigid Dynamics. The better students are advised also to read Fourier's Series and Spherical and Cylindrical Harmonics.

The number of students in these classes may be taken as roughly:— First Arts, 18; Second Arts and First Science, 12. The other two classes have usually been represented by one or two students.

Beginning in 1914, there will be seven mathematical classes, separate provision being made for Pure Mathematics and Applied Mathematics. The seven courses will be as follows:—

Pure Mathematics, I., Arts.

Pure Mathematics, I., II., III., Science.

Applied Mathematics, I., II., III., Science.

The University of Queensland.

§51. In this University the Professor of Mathematics is also Professor of Physics. He has associated with him a Lecturer in Physics, two Assistant-Lecturers in Mathematics, and an Assistant-Lecturer in Physics.

Mathematics is a compulsory subject at entrance. The details for the different Faculties (Arts, Science and Engineering) are given on page 25. It is not a compulsory subject for the Arts degree. The general plan of the curricula for the Science and Engineering degrees resembles those of Melbourne and Sydney.

The following Mathematical Classes are held:—

Pure Mathematics, Part I.

Class A. Trigonometry, Algebra, Geometry, Analytical Geometry and Elementary Calculus. Members of this class are expected to have done the more advanced work of the Senior Examination before entrance.

Class B. Trigonometry, Analytical Geometry, Algebra, Elementary Solid Geometry and Elementary Calculus. Members of this class must have passed the Senior Examination in Mathematics before entrance. One of these classes must be taken by all Engineering and Science students in their First Year.

Pure Mathematics, Part II.

The Infinitesimal Calculus and Differential Equations. This class is compulsory for all Engineering students in their Second Year.

Applied Mathematics, Part I.

Elements of Statics and Dynamics, with Hydrostatics. This class is compulsory for all Engineering students.

Applied Mathematics, Part II.

Dynamics of a Particle, Analytical Statics, Rigid Dynamics and Hydrostatics. This class is compulsory for Engineering students.

Honours Course in Mathematics.

Tutorial Classes are held three times a week for Honours students of the Second Year. These classes read Elementary Analytical Geometry of Three Dimensions, Differential Equations, The Infinitesimal Calculus, Projective Geometry, and Dynamics of a Particle.

The arrangements for Third Year students include courses in Higher Analytical Geometry, Analysis, Theory of Attractions, Rigid Dynamics, and Hydrodynamics.

This work is solely for Honours students.

During the first term of each year a course in Spherical Trigonometry of about 20 lectures is given.

Science instruction bulks so largely in the scheme of the University that a large proportion of its students are to be found in the mathe-

matical classes. The attendance in 1913 was as follows:—

Pure Mathematics, Part I.—Class A	.. .. ..	7
Class B	.. .. ..	47
Part II		33
Applied Mathematics, Part I.		41
Part II.		15

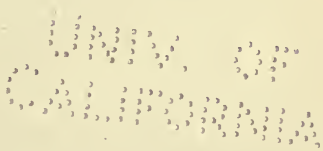
The University of Western Australia.

§52. This University has just begun its work. The Professor of Mathematics is also Professor of Physics. He will probably have Assistant-Lecturers in each of these subjects associated with him.

In Mathematics it is proposed to have a Three-year Course; the first year's work being much the same as that of the Senior Public Examination in Melbourne or Sydney. In the second year Higher Algebra and Trigonometry, Analytical Geometry, the Calculus and Differential Equations will be read. In the third year further work will be done in these subjects, and Astronomy, Spherical Trigonometry and Solid Geometry will be added.

Tutorial Classes will be arranged for Honours Students in selected branches of Mathematics.

The work in Applied Mathematics will be of a similar range, and be taken in connection with the Physics class.



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